Journal of the Society of Arts.

FRIDAY, APRIL 17, 1868.

Announcements by the Council.

Ordinary Meetings.

Wednesday evenings, at Eight o'Clock :—

April 22.—"On the Cultivation of Beetroot, and its Manufacture into Sugar." By W. A. Gibbs, Esq.

April 29.—"On Progress in Oyster Culture." By Harry Lobb, Esq.

Albert Medal.

The Council will proceed to consider the award of the Albert Medal at their first meeting in May next. This medal was instituted to reward "distinguished merit in Promoting Arts, Manufactures, or Commerce," and has been awarded as follows :—

In 1864, to Sir Rowland Hill, K.C.B., "for his great services to Arts, Manufactures, and Commerce, in the creation of the penny postage, and for his other reforms in the postal system of this country, the benefits of which have, however, not been confined to this country, but have extended over the civilised world."

In 1865, to His Imperial Majesty the Emperor of the French, "for distinguished merit in promoting, in many ways, by his personal exertions, the international progress of Arts, Manufactures, and Commerce, the proofs of which are afforded by his judicious patronage of Art, his enlightened commercial policy, and especially by the abolition of passports in favour of British subjects."

In 1866, to Professor Faraday, D.C.L., F.R.S., for "discoveries in electricity, magnetism, and chemistry, which, in their relation to the industries of the world, have so largely promoted Arts, Manufactures, and Commerce."

In 1867, to Mr. W. Fothergill Cooke and Professor Charles Wheatstone, F.R.S., in recognition of their joint labours in establishing the first Electric Telegraph.

The Council invite Members of the Society to forward to the Secretary, before the 15th April, the names of such men of high distinction as they may think worthy of this honour.

Subscriptions.

The Lady-day subscriptions are due, and should be forwarded by cheque or Post-office order, crossed "Coutts and Co.," and made payable to Mr. Samuel Thomas Davenport, Financial Officer.

Proceedings of the Society.

Food Committee.

The Committee met on Wednesday, March 25th. Present — B. Shaw, Esq. (in the chair); Mr. Harry Chester, Mr. E. Hollond, Captain Grant, Mr. G. F. Wilson, F.R.S., Mr. J. T. Ware, Mr. Neville Lubbock, and Mr. E. C. Tufnell.

Mr. Frank Buckland attended and gave information with respect to the supply of oysters, lobsters, &c.

Mr. Chester—Before you begin, I wish to ask a question with regard to the extension of the inland fishery districts. I understand that a district is formed when the country gentlemen in the neighbourhood wish for it, but is there any arrangement under which the Secretary of State, or one of the inspectors of fisheries, can put the thing in train, so as to show the country gentlemen the value of having a district, and get them to act?

Mr. Buckland—That is not exactly the business of an inspector; but both Mr. Walpole and myself take much the same view of the matter as you do. I shall be very glad to see the River Eden and its tributaries made into a district. I am going to give a lecture at Southampton, and hope to get the Hitchen and Test made into a district; and we also are making arrangements to the same end with regard to the Arun and Rother. I will now proceed with my evidence on sea fisheries. The first point to which I would call attention is the cultivation of oysters; and in the first place I would enumerate the localities where, as far as I know, oysters exist—proceeding downwards from the N.E. side of England. At Berwick-on-Tweed there are no oysters, only mussels; next we come to Holy Island, I believe, which is a very promising place for oysters; it is the property of Lord Tankerville. At the mouth of the Alne and Coquet there are no oysters; too much sand. A great bed of sand, in fact, appears to extend from here to Norfolk; and where there is sand there are no oysters. At the mouth of the Tyne there are no oysters, but abundance of mussels; the same with the Tees and the Wear. At the mouth of the Trent there are no oysters; I believe there are mussels. Just off the north coast of Norfolk there are a few oysters, not enough to be of great commercial value; but the mussel cultivation in the Wash and the Humber, is very important. The head-quarters of the oysters are off the coast of Essex. There are very few in the Orwell at present, but it seems likely to be a good place for them. Then we come to the Colne, where there are magnificent oysters, now very scarce; and at Blackwater they are very good. This district and hereabouts is the great breeding ground of all the so-called "natives." Then we come to the mouths of the Crouch and the Roach, where the oysters are very good. My friend Mr. Fred. Wiseman, who is here, will give you some information as to this locality. The peculiarity of the Roach oysters is that they are green-bearded; the bodies are of the usual colour, but the beards are green. Mr. Wiseman will tell you that these are the oysters which for years have been sent to Ostend, whence they are sent to Paris, Berlin, &c., and are sold as *Huitres d'Ostende*, and as they are much prized by Englishmen abroad, Mr. Wiseman is anxious to introduce them into the London market. Then we come to the mouth of the Thames; about Shoeburyness it is too sandy for oysters, but there are some very fine ones called Hern oysters, opposite Sheppey. Then we come to Whitstable, which produces the best oysters we have, worth now £8 per bushel. Next we come to Herne Bay, where there is an oyster company, with which I am connected. Then there is a long blank until we come to Selsey Bill, where there are a few oysters, but it is not a place of much importance in our list. A district of very great promise for oyster cultivation is that about Portsmouth and Chichester, where

there are a great many creeks, and not far off is the celebrated Hayling Island Oyster Fishery. There are several fisheries in the Isle of Wight, one at Medina, and another at a place called Branding Harbour, the property of Captain Kulbach, where it is proposed to form a company. All along the Solent and off Spithead the oysters have a handsome shell, but they are not very fat. Opposite the Hampshire Stour there are very few. Next we come to Poole. At this place there is a natural bank of shells, but at present no oysters. A lady has been trying to cultivate them there under the French system, but as yet with only partial success. There evidently have been oysters there, and I see no reason why they should not come again. There are none, I believe, in the Axe; in the Exe there are a few of what is called "Exe Bright" oysters, but I am afraid the bottom is rather too sandy. Sand is the great enemy to oysters; for a sand storm may come and bury the whole bed, and kill any oyster placed near it. There are a few oysters at Plymouth, but no great number. At Falmouth there are pretty fair oysters, but, unfortunately, some of them are green, not only in the beard, but in the body. Then we come round to the Severn, where there are no oysters, and never will be; there is too much sand. At Swansea we find rough, sea oysters, but the young ones are pretty fair in quality. There are not many in Carmarthen Bay, owing to the sand. Milford is a very first-class place indeed for oysters, and they are as fine there as ever I have seen them. From there all up the Welsh coast there are no oysters until we come to Beaumaris, from which place Liverpool market is largely supplied. The beds there are not natural, the oysters having been laid there. Further to the north, I believe, the coast is all too sandy. The localities, therefore, where oysters can be cultivated on the coast of England, are considerably limited.

The Chairman—Is there any real objection to the green oysters?

Mr. Buckland—The green-bearded ones from the Roach are very good, but the Falmouth ones will not do at all. I do not know whether they are eaten in the neighbourhood. I believe that not all these Falmouth oysters are green. I now come to the Irish oyster fisheries, of which I have a list made out by the late Mr. Ffennell, which shows a very different state of things to what we have seen in England, for all the bays and inlets on the west coast are very favourable for oysters. The beds are at Lough Foyle, Blacksod Bay, Achil Sound, and Clew Bay; Kilkerran Bay, Burterbuc Bay, and Rosmuck; Galway Bay, Waterford, Burterbill, Wexford, Wicklow, Carlingford, Cork Harbour, Belfast Lough, Red Bank Burrin, Shannon, Kenmare Bay, Lough Swilley, Sligo, Ballisdore Bay, Killary Bay, Ballynakill, Clifden, Tramore. Thus, there are twenty-one places in Ireland where oysters are bred, and from some of these places they are brought and laid down to fatten in the English beds. Oysters are exceedingly dear, and will be still dearer. Fine ones are now worth 2d. each; they will be worth 3d., and then 4d., and perhaps 6d. each, and the question is, what is the cause of this high price? Of course the first reply is, their scarcity; but the next step is, what causes the scarcity? Some people say it is due to over-dredging; but Mr. Wiseman has been at work at this question for the last five or six years, and we agree that over-dredging has nothing to do with it. It is a simple case of cause and effect. According to my calculations an oyster brings forth about 800,000 young ones in the months of May and June. That is the number I have found in one shell. I do not know how often breeding takes place in the oyster's life, but after spawning we know that the oyster will fatten. I arrived at the number by weighing the spat from the oyster, and then carefully weighing a grain, and getting the number in that grain counted, which was no easy task, owing to their minute size. In my museum I have some six or eight which have been counted in that way, and the result is about what I have stated. These numbers of young oysters were known to be extruded from the parent oyster, and if the crop succeeded they ought to be found upon the shells placed to receive them, but this is not the case; you do not find them. It is like sowing corn in a ploughed field, and waiting for it to come up, and it does not come. That is the cause of the scarcity. It will then be asked, do these little oysters die? They float a certain number of hours or days in the sea, and then adhere to something, and between the time of their birth and this attachment to a shell or stick, they die. What, then, is the cause of their death? Mr. Wiseman and myself have been investigating this matter for some time, and we both believe that it is a question of temperature; that when these little creatures are floating about, a cold wind comes and chills the water, and they die. I have been trying experiments for the last two years with little oysters, and what one does they all do. I have tested the heat of the water with a delicate thermometer, and I find that by subjecting the spat to different degrees of temperature, I can kill them at once, or partially kill them, and again resuscitate them. I find that they require a very high temperature to be well and hearty. Now, we have had for these last four years very cold nights in June, and in those cold nights I believe that something happens in the sea similar to what happens in my experimental bottles, where I see that a low temperature causes the young oyster to collapse and go to the bottom. The French have bred oysters for some years past, and the idea has got abroad that because the French can do this to a large extent, therefore we can do the same. But this is a great mistake. If a man said—"I have seen vines growing extensively in France, let us get up a company and grow them in Essex or Hampshire," of course the scheme would come to grief. The temperature which is suitable for growing vines from which to make brandy, is suitable to the growth of young oysters. You may put in stones and tiles, or anything you like, but the oysters will not stick to them as they do in a warmer climate than that we have lately had in June. I believe therefore that temperature is the cause of the failure which has been going on ever since 1860. In 1859 there was a very good crop, but ever since it has been very bad. If you leave the oysters, and do not dredge them, the result will simply be that the vermin, the star fish, and so on, will eat them, and the ground will also get covered with mud. At Hayling Island, where they have had such great success in the cultivation, the weather is much warmer than in Essex, as we know by delicate and consumptive persons going to the Isle of Wight as an asylum. Every oyster has a sort of physiognomy of its own, and after some practice you can tell almost with certainty where he comes from. This physiognomy depends very much on the quality of the soil and water on which they are laid, and from which they derive their nutriment, and it is a curious fact that with change of situation an oyster will change its appearance. Lay an Irish oyster on English ground and it will grow a new shell, and taking its material from the water in which it is, will assimilate in character to those indigenous to the place. Here is one, say from Scotland, which has been put into a good English feeding-ground, and in the course of a year it has nearly doubled the size of its shell. It is very necessary in cultivating oyster-beds to know what should be laid down to catch the oysters; and at my museum at the Horticultural Gardens, I have specimens of various substances which are useful for this purpose, but there is nothing at all equal to that which is pointed out by nature—viz., the old oyster shells themselves.

The Chairman—What is the farthest extreme point northwards that you know of oysters flourishing?

Mr. Buckland—There are none, I think, in the Baltic; there are a great many on the west coast of Norway, and on the west coast of Ireland, the reason I believe being that those parts are more exposed to the

action of the Gulf stream. Oysters certainly breed much more freely on the Irish coast than on that of England. There are also oysters on the east coast of Ireland, but not so many as on the west.

Mr. HOLLOND—The waters of the Connecticut are very cold, the river being frozen over until April, but that river is full of oysters.

Mr. BUCKLAND—The water ought to be warm there in the summer; and you must recollect that in order for oysters to fatten they require cold water, but warm to breed. Deep-sea oysters do not spawn until August or September, while those in shallow water spawn in May and June.

The CHAIRMAN—Allow me to read to you a short extract from what Mr. Blake said:—"Something tremendous might be done by artificial culture," &c.

Mr. BUCKLAND—The question of companies is a very serious one, because oyster culture is so uncertain; you may spend a large amount of money, and after all the plans adopted may not answer. Lord Dunmore laid a large number of oysters in the Island of Harris, and the people came in the night and swept them all away. I think it would be a very good thing to cultivate the foreshores, if you can manage it in suitable localities, without infringing upon public rights. Then I come to the question of the mussel fisheries, and that is almost as important as that of oysters, because mussels are used as bait for deep-sea fish. I was at the Board of Trade last week with a deputation relative to the destruction of the mussel "scalps," as they are called on the coast of Lincolnshire. There are a vast number of beds there which supply bait for the haddock fishery, and these beds, not being protected in any way, are now being gradually destroyed. They used frequently to get from fifty to sixty tons of mussels weekly, at 40s. a ton, and it is calculated that one ton of mussels ought to produce £40 worth of haddocks, so that the produce of these beds would in that way be worth from £1,000 to £1,200 a year. Now the farmers are taking these mussels and putting them on their fields for manure, using the young fish that ought to be allowed to grow to maturity in order to form bait. This question is very important at the present time, because if there is no bait we shall have no haddock. All the mussel beds at the mouths of the Wear, Tyne, and Tees ought to be cultivated. These mussels are eaten largely in London as human food.

Mr. CHESTER—You attribute the approaching scarcity of oysters to over-dredging; would it not appear likely, by analogy, that the scarcity of mussels is, at least in some degree, due to the same cause?

Mr. BUCKLAND—I had that idea at first, but I find on inquiry that plenty of mussels are born every year; there is no complaint of the want of the fall of spat, as in the case of oysters. They are taken away after they are born, before they are grown up. Now I come to whelks; they are exceedingly important, as they afford bait for the cod fisheries in the north. They are also brought to the London market, and sold as food.

Mr. CHESTER—have any attempts been made to fish for haddocks and cod with artificial whelks and mussels?

Mr. BUCKLAND—I don't see how you could make artificial whelks; an artificial minnow costs 5s., and when you can get whelks four or six a penny, it would not do to buy artificial ones at such a price. I think the fish would be too knowing to be taken in like that. We now come to lobsters and crabs; and this is very important, for lobsters are certainly diminishing in number. The cause of this decrease I am not prepared to state, but my friend Mr. Jonathan Couch, of Polperro, writes to say that he finds in former times the fishermen were in the habit of putting the female crabs back again into the water, taking off a claw as a sort of toll, knowing it would grow again. Mr. Henry Lee, who is here, can also state what was the practice at Margate in the case of lobsters.

Mr. LEE—They used to throw back the younger ones. There was a club called the Dredgermen's Club, all the members of which were bound by the rules to throw back all lobsters below a certain size, and on satisfactory proof of their having done so, a certain sum was allowed them by the club.

Mr. BUCKLAND—A great part of our supply of lobsters comes from Norway. I must tell you that I keep up, through the medium of *Land and Water*, a correspondence with many parts of the fishery world, and from a clergyman who knows a great deal about Norway I have got some very interesting statistics as to the export of lobsters from that country. In 1855 there were exported 814,000; in 1856, 960,000; in 1857, 717,000; 1858, 553,000; 1859, 881,000; 1860, 1,333,000; 1861, 1,480,000; 1862, 1,217,000. But this is not going to last, and I think the reason is that they catch the female lobsters when they are what are called "berried hens." In lobster salad you have the red berries or eggs of the lobster, which would eventually become young lobsters. I do not know why the Norwegians allow them to be caught at that time. They have a close time for lobsters, from the 15th July to the 15th October, but I think it ought to begin earlier, or the fisheries will suffer. I think lobsters might be hatched artificially in many parts of England and Scotland. The first requisite is a rocky coast; they will not thrive where there is mud. If you could get a lagoon among rocks, stopped up to prevent their escape, but allowing the water to go in and out, you probably might grow them. Mr. Lee and myself, and two or three other gentlemen, have an experimental fishery at the Reculvers, near Herne-bay, and into this I put last spring three "berried hens," which I bought at Gilson and Quelch's, in Bond-street, as I was going down. In a few days the water was absolutely swarming with young lobsters. They all have the power of swimming about more or less, like little fish or tadpoles, for a few days, and then they fall to the bottom, and, as unfortunately the bottom of our pond is muddy, I believe they were all destroyed. If we had had rocks for them to get in they would no doubt have been alive now. We found out that it was necessary to feed them, or they would eat one another. There are many places in Ireland and Scotland where, I should think, lobster culture could be carried on.

Mr. LEE—Some fishmongers at Margate met my suggestion as to hatching out the young lobsters by giving me permission to take all the berried hens. The result was that I hatched out the young from more than a dozen female lobsters, and they were allowed to swim out to the rocks from which the old ones were taken.

Mr. CHESTER—Would not you say it was a very wicked act to make lobster sauce from a "berried" hen, and that it ought to be made felony by an Act of Parliament?

Mr. BUCKLAND—It is contrary to Leviticus, certainly; but when I say to the fishmongers what a shame it is, they say, the gentlemen will have them. I would suggest that the Secretary be directed to write to the Norwegian Government on the subject. I do not think any lobsters come from Canada or North America except as potted lobsters. It is of great importance that there should be a close time for these valuable crustacea.

Mr. LEE—In some places the lobsters have been entirely destroyed through killing the "berried hens."

Mr. BUCKLAND—I think the close time should begin earlier; but, at all events, the Society of Arts should call the attention of the Norwegian Government to the fact that lobsters are sent over here in the spring months full of "berries," and that their fisheries will be injured in consequence if something is not done. I now pass on to the deep-sea fish. I have correspondents who write to me almost weekly in *Land and Water*, which is a paper that has for its chief object fish cultivation. Three clergymen kindly write to me from Great Grimsby, Cullercoats, and Brixham, so that I am pretty well *au fait* at what is going on in the department of sea fisheries. There are between 800 and 900 trawlers

that supply London with fish, and the amount per annum is about 800,000 tons. The best trawled fish fetch about £7, and the worst about £2 per ton, wholesale price at Billingsgate. There is a chart of the North Sea, which has been marked out by a gentleman (Mr. M. Thomas) who owns a fishing smack, the *Hurricane*, from which you will see that fish are caught in different localities, and the kind varies in different places. Each fish seems to have a *locale* of its own. The whole of the North Sea, from the east coast of England going up to Norway, is a sandy plain, more or less, and upon this large plateau of sand you find the flat fish, which correspond, in my mind, to desert animals on land. Directly you get to another submarine country you find another piscifauna. These North Sea fisheries are of the greatest importance to us as a nation, but they are certainly diminishing; fewer fish are caught than were formerly. An inquiry has been instituted by the Commissioners of deep sea fishing, and they propose that there shall be no legislation, but that things shall be allowed to go on as they are. Mr. Lee and myself, and also Mr. Lord, have been inquiring into this matter, and it seems to us that the question is a little jumbled. In the first place people say the trawlers bring up a great quantity of spawn. But what is the spawn? It is probably not the spawn of fish, but of some marine creatures. How is it possible for a 2 or 3 inch mesh net to bring up the spawn of herrings, unless it is gelatinous and adhesive? My own opinion is that trawling may do mischief—I do not say that it does—inasmuch as it kills the little fish. There is a weir down at Hampton, near Herne Bay, in which I found a basketful of little fish dead—sole, plaice, flounders, and so on. This was not 300 yards out to sea, which shows that these creatures come in to spawn upon the foreshore. The result of the trawling, as far as I have seen it is, that the net is dragged along the bottom of the water, and as the water pushes it backwards, the pieces of string composing it are drawn together, and everything is caught within it, and when the net is hauled on board a great many of these little fish drop out, dead. I do not think the deep-sea trawlers do so much harm as the in-shore boats. The former, Mr. Thomas informs me, do not work in less than 10 or 15 fathoms water. I do not at present know how that is to be remedied, but I certainly think that for these fish there ought to be a close time. A short time ago my sea-fishery correspondent wrote to say that the fishermen could catch no soles, and I wrote back to say that I was delighted to hear it, because I believed the soles had gone away from the deep-sea water, where they take up their winter quarters, on to the sand-banks on the coast of Holland or England to spawn. A few weeks after, I was sorry to hear that they had found them again. We have consulted with fishermen, and asked them what they want done, but they cannot make up their minds; they only say they want the number of smacks diminished. I cannot see how this is to be done. I really wish the deep-sea fishermen would say definitely what they really desire. My own idea is, that a gentleman should be appointed to go and live on board the smacks for a certain number of months in the year; some one like my friend Mr. Lord, who has been used to this kind of work; it must be a competent man—who should take his microscope and scalpels and other apparatus, and see what the state of the fish really was at different periods of the year, and report upon it. He should go from smack to smack, and from bank to bank, until we really had full information as to the habits of the fish, and the systems of fishing carried on. By adopting this course for a few years a vast amount of practical knowledge concerning deep-sea fishing would be accumulated, and that is really what we want. We know nothing at all about the habits of sea-fish, and until we do it is perfectly impossible to have proper legislation.

Mr. Chester—Do you see any reason, Mr. Buckland, why all fish should not be sold by weight? Salmon is sold at so much a lb., but turbot and soles, and all other kinds, are sold by the fish, and you cannot tell how much you really are getting for your money.

Mr. Buckland—I cannot answer that question, but I suppose the fishmonger gets more out of it that way. In Manchester, soles, I believe, are bought by the pound.

The Chairman—Allow me to ask whether, in considering the question of trawling, you have taken into consideration that young fish which may be brought up by the trawl may be killed by its passing over them?

Mr. Buckland—As far as I understand a trawl, if any fish once gets within it, it is all up with him. There is a little mistake as to the trawl having an iron frame. There are two iron runners, like sleigh irons, but the bottom of the trawl itself is a rope. The Barking system is to wind rope round a chain so as to weight it. The Torbay system is to use rope alone. Any little fish that got under it would certainly not be benefited. The great point on which I differ from the commissioners is as to various grounds being trawled out; some have been trawled out. But we shall really know nothing about these matters until we have somebody living on board.

Mr. Chester—Do you know at present, really, whether whitebait, anchovy, and sprats, are young fish, or whether they are distinct and separate varieties?

Mr. Buckland—I can only tell you what I know, and that is, that when you eat whitebait you eat about five different kinds of fish.

Mr. Chester—You do not believe it is a distinct species?

Mr. Buckland—I want to see an old whitebait in spawn.

Mr. Chester—Ought we not to ask Government to have large aquaria of sea and fresh water fish; to see whether a whitebait ever becomes an anchovy, or a sprat a herring?

Mr. Buckland—That is most important, and that is what Mr. Lee and myself are trying on a small scale. I should be very glad if Government would take it up on a large scale. I have no doubt they will after a time.

The Chairman—Your desire is that Government should appoint, not so much an inspector as an inquirer, to obtain information, and also that aquaria should be formed in which the habits of these animals might be watched, and experiments conducted?

Mr. Buckland—Exactly. Since I was here, some gentlemen called on me to make inquiries respecting an aquarium on a large scale, but after giving them the information, I have not heard any more of it.

Mr. Lee—They are going to form a large aquarium at Scarborough first, at a cost of £10,000.

Mr. Buckland—It could never be done in London on account of the cost of sea-water.

Mr. Hollond—Have you heard the decrease in the fish off the east coast of England attributed to the fouling of the water caused by so many steamers passing over the sand banks?

Mr. Buckland—Nothing of the sort has been mentioned in the letters of my correspondents at Cullercoats and Whitby, but if such statements are made we will inquire into it. Another point has reference to the use of ice in trawlers. Being out sometimes for several days they use ice to keep the fish fresh for the London market, each vessel using from 5 to 16 tons in the winter, and from 16 to 35 tons in the summer. Mr. Thomas informs me that each trawler uses about 80 tons. His *Hurricane* takes one and a-half ton of ice per week. This is rather expensive; indeed, one gentleman is reported to spend between £2,000 and £3,000 for ice in one year to preserve his trawled fish; and if some process could be discovered for producing a low temperature without the use of ice it would be a great advantage.

Mr. Foster—There are several people hard at work upon that problem now, but the great difficulty is to do it sufficiently cheap.

Mr. Buckland—The cod fisheries I have but a few words to say about, for though it is a very important

fish, its power of multiplication is so great that I have no fear of its being destroyed. I calculated the other day that the roe of a cod contains 6,800,000 eggs, nearly twice the population of London. Still the roes of cod are used in a way they ought not—as bait for the sardine fisheries off the French coast. However, the cod does not want much protection. I should like also to say a word on the Iceland fisheries, which are important to us. The best of the fish is sent to Spain, where it is much esteemed under the name of "Bildals," and the inferior qualities are sent to England. Then we come to pilchards. They come to Cornwall, but no further, and are very rarely sent to the London market; why, I cannot conceive, because they are salted for the Spanish market, where they are much esteemed, and fetch about £3 a ton. It is a question worth inquiry why they should not be brought to London and sold in the markets. As regards herrings, their power of reproduction is marvellous, each roe containing, I find, 19,000 or 20,000 eggs, but still they are not so plentiful as they might be. The unfortunate thing about them is that we can only catch them at the time they are in spawn. They appear to me to come from the deep water into the shallow, not to undertake that beautiful tour which Mr. Pennant described—where they go no human being knows, except that they go into the deep water. There can be no useful legislation until more is known of their habits, but I think the "inquirer" ought to find out and report to the authorities at what time they should be protected. My friend Mr. Couch, the celebrated naturalist, of Polperro, sent me a very interesting account of the herring's spawn, which was observed off the coast of Cornwall. He says, on January 25th:—"A few days since my attention was directed to a fishing drift-net, which was filled with spawn known to be that of the herring, and on inquiry I found that all the nets in the boats were equally filled with this spawn, in some more abundantly, so that one of the fishermen believed there must have been many bushels, and one of the most intelligent of these men assured me that it dropped from the fish as the nets were hauled on board, and that too in such abundance that as he stood in his boat the quantity reached to his knees. This was between this place and Plymouth. The net floats at about three fathoms from the surface, in a depth of about 25 fathoms. The nets of the boats which assemble at Plymouth from the herring fishery are calculated to reach considerably more than 100 miles, and if all of them are filled with this spawn, in a manner like what we have seen and been informed of, the quantity of this destroyed must vastly exceed the number of the fish taken. So far as the public benefit is concerned, such weather as will render it imprudent for the nets to be shot must be of vast benefit. Storms are good for something." If there were such a public officer appointed as I have spoken of he would order the fishing to be stopped in such a case, or do something, but it will not do to have any person unless he is a naturalist. My theory is, protect the fish while spawning, and then I would give you leave to catch them any way you liked at other times. But the protection must be sincere and real. Mackarel have about 56,000 eggs in the roe, and they also are taken in spawn, which ought not to be. Haddocks the same, and soles the same. I can only sum up my evidence by saying that we know nothing about these sea fish.

Mr. Chester—Have you any opinion as to the comparative nutritive value of these fish in and out of spawn?

Mr. Buckland—We never eat herring except in spawn, or just after, but by analogy with all other fish, they would be much better at other times. I conclude by saying that Mr. Lee and myself have this experimental fishery at Reculvers, which we should be pleased for the committee to see. I have also a museum of economic fish culture, which I am making at my own expense, the South Kensington authorities having granted me a good site for it in the Horticultural Gardens. I take a cast of every large fish that I can hear of (they are kindly lent me by the fishmongers, especially Messrs. Gilson and Quelch, of Bond-street; Thomas Grove, of Charing-cross; Charles, of Pimlico; and Grove, of Bond-street), and collect every specimen that seems likely to throw light upon this important subject. I am happy to say that the public are beginning to be aware of the importance of this kind of inquiry in the way of lessening their own expenses, for that is the object of all our researches.

Mr. Chester—Can you say anything about eels?

Mr. Buckland—Eels go down the rivers when the salmon are coming up; they spawn in the estuaries. The little eels come up at this time of year, and in certain rivers, such as the Parrett, in Somersetshire, vast quantities of these elvers, as they are called there, are taken. They are made into cakes and fried. I think, very likely, there are large tracts of country doing nothing at all, where eels might be cultivated with a good chance of paying a dividend. There is a question whether the parent eels return to the rivers; I think they do, or else it would be difficult to account for the large eels sometimes found in fresh water. I have not turned my attention to the question of supplying fish to rural districts, but I should think it could be done by means of costermongers. I will make inquiries on that point.

Mr. Frederick Wiseman, Oyster Merchant—I have very little to add to what has been said by Mr. Buckland on the subject of oyster culture. I quite agree with regard to the low temperature of the water being the cause of the failure. The first failure was in 1860, when it was so complete that, although a sum of money was offered for spat, not one was found. Since then, the fall of spat has been very partial; there was very little in 1861, and even up to the present time, I may say that there has been almost a failure in the spat. Some have attributed the failure to over dredging, but there never was a greater mistake. I have a little pamphlet in which it is stated that all the available oysters have been eaten, and none placed in the beds to replace them; that the demand has exceeded the supply; but this is not the cause of the failure. Oyster beds are not dredged out in that way; I speak of private beds. All the oysters sold in London as Whitstable natives are parent oysters, four or five years old. We do not sell the little ones; and even in the case of public beds, where young oysters are dredged up, they are sold to private persons for feeding. I have kept a diary of the wind and weather since 1858; and on the night of the 10th June, 1860, after a hot day, there was a frost, and the temperature of the water went down ten degrees. I believe the temperature has been colder in June since 1858 than it was before. If you can once get the spat to adhere no amount of cold will destroy it afterwards. In 1858 we had a hot summer, and there was abundance of spat. It is not the fact that long before 1858 there was a gradually increasing scarcity and dearness of oysters. I should think they were as cheap in 1857 as in 1825. They were not dear in 1858, or even in 1860; perhaps 30s. or 40s. a bushel; I have sold native oysters at 18s. 6d. a bushel not many years back. By selling oysters in the way we do, only the parent oysters, it would be impossible to denude the beds if there was spat to replace what was taken away. Oysters begin to breed from 2½ to 3 years old; we do not sell them until after they have spatted; we never sell one under four years old. They spat in June and July, and we do not sell them until the 1st September, so that they have all had time to spawn; but, unfortunately, it has perished from the low temperature. It is not likely we should overdredge our own beds. I have been in the trade more than thirty years, and my father and grandfather were in it before me, so that we ought to know something about it. I have had the benefit of my fore-

fathers' experience, but, at the same time, I am only too glad to try anything fresh. I have tried cultivating them in a tank; it has not proved very successful, but I mean to continue the experiment. The oyster spat must float for some time, because we sometimes find it on the bottom of the boats. I attribute the success of the cultivation at Hayling Island to the temperature. It is ten degrees higher there than at Faversham. I never knew the temperature in the river Roach or Crouch higher than 71°, and I have found it 82° at Hayling Island.

Mr. Chester—Has it not generally been found that the average temperature of the coast has risen of late years?

Mr. Buckland—We have had very cold summers.

Mr. Chester—As a whole, taking the last twenty-five years, would you not say the temperature had improved?

Mr. Buckland—It may be so; but it is not a question of average.

The Chairman—The Romans used to get oysters from Utupium, and the climate must surely have been colder then than now.

Mr. Wiseman—I have known of a failure in one year before, but never such a succession.

Mr. Tufnell—At Hayling Island the effect of the Gulf Stream comes direct, but on the Essex coast it has had to travel all round the north of Scotland.

Mr. Wiseman—There is no doubt the water is much warmer there than on the Essex coast. If the failure were caused by the want of parent oysters, how is it that in 1860, when oysters were abundant, we had no spat?

Mr. Chester—No doubt the temperature has a good deal to do with it, but I fancy there must be some further cause for the failure.

Mr. Hollond—I do not understand how the American rivers, which are frozen up for many months, are so stocked with oysters. The Hudson is very cold in July.

Mr. Buckland—I understand it is very hot there in August and September, and the oyster may spawn then.

Mr. Hollond—Would not the same rule operate in England, and if the weather were unusually cold in April and May would that not drive off the spawning to the last week in June instead of the first?

Mr. Buckland—It might in some cases, but not in all. I have had nine samples of oysters from America sent me, and some I have put into the fishery, where they are doing very well. It occurred to me that they might be made hardy, and able to spawn in a lower temperature than our native oysters. Oysters grow from May to the end of August, after which they fatten. A few months ago an oyster bed was discovered off Blankenberghe, on the Ostend coast, which yielded a large quantity of oysters, and I really don't see why the coast-guard boats should not occasionally put a dredge overboard, as in that way new oyster-beds might be discovered of which we know nothing. I am convinced, and so is Mr. Wiseman, that the failure of the spat is from lowness of temperature, and in giving you this evidence we have told you what has cost us much time and money to find out. We are still working at it, and hope yet to arrive at something practicable. I am much pleased that the Society of Arts is taking up the subject of fisheries.

Eighteenth Ordinary Meeting.

Wednesday, April 15th, 1868; C. W. Siemens, Esq., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Eyre, Major-General Sir Vincent, C.B., Athenæum Club, S.W.
Lawrence, Edwin, LL.B., B.A., 94, Westbourne-ter. W.
Scott, John, 21, Newton-road, Bayswater, W.
Solomon, Asher, 8, South-street, Finsbury, E.C.

The following candidates were balloted for, and duly elected members of the Society:—

Drummond, Peter Robert, Perth.
Foster, George, Rochford, Essex.
Jeffery, Walter, 35, Eastgate-street, Gloucester.
Wilson, Edward, Hayes, Kent.

The Paper read was—

ON LIQUID FUEL.

By Benjamin H. Paul, Esq.

The economy of fuel is a subject of so much importance in a variety of aspects, and it affords so much scope for improvement, that any suggestion made with that object is always deserving of full consideration; and, even if such suggestions should be impracticable or erroneous, it is at least worth while to demonstrate clearly the circumstances which may be considered as justifying an adverse opinion. That such a course is appropriate in regard to a project which is expected to involve a reconstruction of our navy and a radical revolution in steam navigation, will, I apprehend, be readily admitted.

The proposal to substitute for the coal now used as fuel in steam vessels some kind of liquid combustible, is an off-shoot of the excitement which has prevailed during the last few years in regard to the discovery of vast quantities of petroleum in America; and it was that material which was in the first instance recommended as the substitute for coal. A commission appointed in America some years ago, to investigate the subject reported that petroleum was beyond doubt more than twice as effective as anthracite coal in the production of steam, and that steam could, by the use of this material, be produced in less than half the usual time.

It was an inference by no means unnatural that if this were the case, and if coal could be superseded by this material as the fuel of steam vessels, a very great portion of the space required in merchant steamers for the stowage of coal would be rendered available for more profitable cargo; that steam packets might become independent of coal depôts at various points of their passage; and that vessels of war would be enabled to keep the sea for a very much longer time than they now do with coal. Any prospect of such advantages as these being attainable might reasonably have been expected to justify a more thorough and searching investigation of this subject than it has yet received in this country.

Besides petroleum, several other analogous materials have been proposed as substitutes for coal; for instance, the oil obtained by distilling particular kinds of coal, or the shale which occurs in coal formations, and more recently the oil known as "dead oil," which is one of the products obtained in rectifying the coal tar of gas works. All these materials resemble each other closely in being composed chiefly of carbon and hydrogen, which are, in various proportions, the combustible and heat-producing constituents of all kinds of fuel. For the application of these materials and of liquid fuel generally, various methods have been proposed, but before speaking of them it is desirable to consider what is the evaporative power of these materials respectively, since that is a very important point to determine in regard to the question as to the relative merits of these different kinds of fuel.

The heat generated by combustion has been made the subject of the most careful investigation; and since the time of Lavoisier, Laplace, and Rumford, the more precise measurement of the amounts of heat capable of being produced by the combustion of carbon and hydrogen, has been repeated by several physicists with results which agree so closely, that they may safely be regarded as well established. The names of Dulong, Despretz, Andrews, Favre, and Silbermann are, moreover, an unquestionable guarantee that these results, and the methods by which they were obtained, are perfectly trustworthy. According to these results, the maximum heat-producing capabilities of carbon and hydrogen are

in the ratio of 1 to 4·5. The actual quantities of heat generated by the combustion of a pound of carbon or of hydrogen are as follows:—

Relative Calorific Power.

	Pound.	Heat units.	
Carbon	1	14,500	1·00
Hydrogen	1	62,032	4·28

The heat unit here referred to is the quantity of heat which raises the temperature of one pound of water one degree Fahr. (from 40° to 41°). Therefore, the numbers given in the table represent the quantities of water capable of being heated one degree Fahr. by the conversion of one pound of carbon into carbonic acid gas, or of one pound of hydrogen into water. As there are, in the Fahrenheit thermometric scale, 180 degrees between the freezing point and boiling point of water, those numbers divided by 180 give the corresponding quantity of water capable of being heated from 32° to 212° Fahr. Again, the quantity of heat required to convert a pound of water at 212° Fahr. into steam of the same temperature, is nearly five and a-half (more exactly 5·37) times as much as that requisite to heat a pound of water from the freezing point to the boiling point; therefore the quantities of steam capable of being produced from water at 212° Fahr. by the total heat generated in the combustion of a pound of carbon or of hydrogen, are of course ascertainable by dividing the number of pounds heated from 32° to 212° Fahr. by 5·37. These several quantities are given in the following table:—

Quantities of Water

Heated,		or converted into steam,	by the heat generated in combustion of
From 40° to 41° F.	From 32° to 212° F.	From water at 212° F.	
lbs.	lbs.	lbs.	lbs.
14,500	80·55	15·	1 carbon.
62,032	344·62	64·2	1 hydrogen.

These quantities of 15 pounds and 64·2 pounds of water convertible into steam by the total heat generated in the combustion of a pound of carbon or of hydrogen, represent what is termed the "theoretical evaporative powers" of those substances. By the term theoretical, however, it is not to be understood that these values are in any degree imaginary or assumed; they represent actual facts, which have been established as the results of positive observation, and they are theoretical in reference to the practical application, of fuel only in this sense, that these results are not realised in ordinary practice. The reason of this is not the existence of any uncertainty that the total quantities of heat generated by burning a pound of carbon or a pound of hydrogen are respectively capable of converting 15 pounds and 64·2 pounds of water at 212° Fahr. into steam, but it is simply the fact that, under ordinary circumstances, only a portion of the total heat generated in either case is ever *available* for the production of steam. The statement of the theoretical evaporative power of fuel, or of carbon and hydrogen as constituents of fuel is therefore—like the statement of relative calorific power—only an expression of the relative capabilities, and it indicates in this respect a limit which, though it cannot be exceeded in any case, is never fully attained in practice.

In order to ascertain what portion of the heat resulting from the combustion of carbon and hydrogen is available for producing steam, it is necessary to consider what are the conditions under which fuel is usually burnt, and what becomes of the heat generated in the two cases. In making this inquiry it is also necessary to remember that the several substances concerned in the combustion of fuel require different quantities of heat to produce equal increments of temperature in equal weights, as stated in the following table:—

Quantities of Heat.

			Heat units.	
One pound of	Carbonic acid gas requires..		·217	To raise its temperature from T to T + 1° F.
	Nitrogen	„	.. ·245	
	Atmospheric air	„	.. ·238	
	Steam	„	.. ·475	
	Water	„	..1·000	
	Water at 212° F	„	966·100	for conversion into steam.

It will be seen that water has by far the greatest capacity for heat, both in the state of liquid and vapour, and that a very large quantity of heat is rendered latent in the conversion of water into steam.

In the combustion of carbon, each pound requires for its conversion into carbonic acid gas, 2·67 pounds of oxygen, which is derived from atmospheric air, and as this contains only 23 per cent. by weight of oxygen, it is necessary to supply about 12 pounds (more accurately 11·61 pounds) of air for every pound of carbon burnt.

In the combustion of hydrogen, 8 pounds of oxygen are requisite for each pound of hydrogen, and to furnish this about 35 pounds (more accurately 34·78 pounds) of air must be supplied.

But fuel is never burnt for raising steam in such a way that the supply of air is only just sufficient to furnish oxygen for the conversion of its carbon into carbonic acid gas, and of its hydrogen into water vapour. In order to maintain combustion it is necessary to remove the gaseous products from the furnace, as well as to supply fresh air continually; and when this is effected, as usual, by the draught of a chimney, the gaseous combustion products become mixed with the fresh air to some extent. The effect of this intermixture would be to retard the combustion of the fuel, if the amount of burnt air or combustion products in the atmosphere of the furnace exceeded a certain proportion. Consequently, it is necessary to prevent this by supplying more air than would suffice to furnish oxygen for combustion, so as to dilute the combustion products and maintain an excess of oxygen in the atmosphere immediately surrounding the fuel in the furnace. Careful observation has shown that in ordinary boiler furnaces the quantity of air requisite for this purpose amounts to as much as that requisite for effecting the chemical change which takes place in combustion, so that the total supply of air to such a furnace is usually at the rate of about 24 pounds per pound of carbon burnt, and about 70 pounds per pound of hydrogen burnt.

Under ordinary circumstances the relation between the quantities of these substances burnt as fuel, the total heat generated, the air supply requisite for supporting combustion, and the furnace gas resulting from it will be as follows:—

Fuel.	Quantity burnt.	Air supply.	Total heat generated.	Furnace gas.
	Pound.	Pounds.	Heat units.	Pounds.
Carbon	1	23·22	14,500	24·22
Hydrogen ..	1	69·56	62,032	70·56

The heat generated in either case is, at the moment of combustion, transferred to the gaseous combustion product, and raises its temperature. In the combustion of carbon, the whole of the heat is effective in this way; but in the combustion of hydrogen, a portion of the heat generated is consumed in determining the vaporous condition of the water produced, in the proportion of nine pounds for each pound of hydrogen burnt. As one pound of water at 212°F. requires 966·1 heat units to convert it into steam of the same temperature, the quantity of heat which becomes latent in this way amounts to 8,694·9 heat units (9 × 966·1) per pound of

hydrogen burnt, or 14 per cent. of the total heat of combustion. That portion of the heat is ineffective, either for increasing the temperature of the combustion product, or for producing steam in the boiler, and it must therefore be deducted from the total heat generated, in order to ascertain the amount of heat available, which is as follows, compared with that generated by the combustion of carbon:—

	Quantity burnt.	Total heat generated.	Latent heat of water vapour produced.	Available heat.	Equivalent evaporation of water at 212F.
	Pound.	Heat units.	Heat units.	Heat units.	Pounds.
Carbon ..	1	14,500	..	14,500	15
Hydrogen	1	62,032	8695	53,337	55

In the combustion of carbon, under the conditions above mentioned, the products constituting the furnace gas amount to nearly 25 pounds per pound of carbon burnt, and they require the following quantities of heat to raise their temperature one degree of Fahrenheit's scale:—

	Pounds.		Specific Heat. Heat units.		Heat units.
Carbonic acid gas ..	3·67	×	·217	=	·79639
Nitrogen	8·94	×	·245	=	2·19030
Surplus air	11·61	×	·238	=	2·76318
	24·22				5·74987

The increase of temperature resulting from the combustion of carbon is therefore found by dividing the number of heat units, representing the total quantity of heat generated, by the number of heat units requisite to raise the temperature of these combustion products, etc., one degree, and it amounts to

$$2{,}522°\text{F.} = \frac{14{,}500}{5·75}$$

In the combustion of hydrogen, under the same conditions, the products constituting the furnace gas amount to about 70 pounds per pound of hydrogen burnt, and they require the following quantities of heat to raise their temperature one degree of Fahrenheit's scale.

	Pounds.		Specific Heat. Heat units.		Heat units.
Water vapour	9	×	·475	=	4·27500
Nitrogen gas	26·78	×	·245	=	6·56110
Surplus air........	34·78	×	·238	=	8·27764
	70·76				19·11374

Consequently, the increase of temperature resulting from the combustion of hydrogen is:—

$$2{,}791°\text{ F.} = \frac{62{,}032 - 8{,}695}{19·114}$$

So far, therefore, as relates to increase of temperature the effect produced by the combustion of hydrogen under these conditions is not much greater than that produced by the combustion of an equal weight of carbon, notwithstanding the great difference in the actual quantities of heat generated, as shown below:—

		Total heat generated.	Available heat.	Increase of temperature.
	Pound.	Heat units.	Heat units.	
Carbon	1	14,500	14,500	2522°F.
Hydrogen..	1	62,032	53,337	2791°F.

We have now to consider what portion of the *available* heat is, under ordinary conditions, *effective* in producing steam. The heated furnace gas, resulting from the combustion of the carbon or the hydrogen of fuel is the medium by which the heat generated is transferred to the water in the boiler; and if it could be managed that, between the moment of combustion, and the time when the furnace gas resulting from it is discharged into the chimney, the whole of the available heat could be communicated to the water in the boiler, the evaporative effect realised might then be equal, or nearly equal, to the theoretical evaporative power of the fuel burnt. But this is never the case in ordinary practice.

The extent to which the available heat could, in any case, become effective in producing steam by direct transmission to the boiler, must, of course, be limited by the temperature corresponding to the pressure at which steam is to be raised. If that were 50 lbs. per square inch, the furnace gas could not be cooled down below 360° F. before being discharged from the heating surface of the boiler into the chimney. The quantities of heat which would in such a case pass away in the furnace gas, without being directly effective in producing steam in the boiler, would amount to 12 per cent. in the combustion of carbon, and to 10·8 per cent. in the combustion of hydrogen, as follows:—

	Quantity burnt.	Furnace gas.	Quantity of heat requisite to produce increase of temperature = 300°.	Equivalent evaporation of water at 212°F.
	Pound.	Pounds.	Heat units.	Pounds.
Carbon ..	1	25	300° × 5·750 = 1,725	1·8
Hydrogen	1	70	300° × 19·114 = 5,734	5·9

These quantities of heat would therefore be wasted as regards production of steam, except in so far as they might be applied in heating the feed-water supplied to the boiler.

But, when, as in ordinary practice, the supply of air for supporting combustion is maintained by the draught of a chimney, the temperature of the furnace gas cannot in any way be reduced below about 660° F. without interfering with the draught of the chimney, and thus a waste of heat is occasioned considerably larger than that just mentioned as being the minimum waste.

In very many instances the furnace gas is discharged into the chimney at a temperature very much more than 600° F. above the temperature of the external air, and then the waste of heat is of course even still greater in proportion as the temperature of the gas is higher.

In the case of furnace gas, discharged at 600° F. above the temperature of the air supplied to the furnace, this waste amounts to 24 per cent. of the available heat resulting from the combustion of carbon, and to 22 per cent. of that resulting from the combustion of hydrogen; these amounts being equivalent to the evaporation of 3·6 lbs. of water at 212° F. per pound of carbon burnt, and to 11·9 lbs. of water at 212°F. per pound of hydrogen burnt.

The amount of heat capable of becoming effective in producing steam cannot therefore be greater than the difference between the total available heat and the heat thus wasted in the furnace gas. This amount is about 76 per cent. of the available heat generated by combustion of carbon, and about 78 per cent. of that generated by combustion of hydrogen. This comparison does not take into account those sources of waste which are due to imperfect combustion, but applies only to such portions of the carbon and hydrogen of fuel as are actually burnt in the furnace. In this case the comparative efficiency of these constituents of fuel in producing steam is as follows:—

Combustion of Carbon.

Quantity burnt, 1 lb.		Equivalent evaporation of water. at 212°	at 60°
	Heat units	lbs.	lbs.
Total heat of combustion ..	14,500	15·	..
Available heat...........	14,500	..	..
Waste heat of furnace gas..	3,480	3·6	..
Effective heat	11,020	11·4	9·8

COMBUSTION OF HYDROGEN.

Quantity burnt, 1 lb.		Equivalent evaporation of water.	
		at 212°	at 60°
	Heat units.	lbs.	lbs.
Total heat of combustion ..	62,032	64.2	..
Latent heat of water vapour	8,695	..	..
Available heat	53,337	..	..
Waste heat of furnace gas..	11,520	11·9	..
Effective heat	41,817	43·3	38

Thus the maximum evaporative efficacy of carbon and of hydrogen is, for each pound burnt, respectively equal to the conversion of about eleven and a half pounds and forty-three and a half pounds of water at 212 degrees, Fahr., into steam of the same temperature, and under the ordinary atmospheric pressure. The extent to which this *efficacy* is *realised* in the ordinary application of fuel for producing steam will depend upon the relative facilities afforded by the rate of combustion and by the construction of the boiler, for the full absorption of the effective heat from the combustion products during their passage along the flues or tubes of the boiler before being discharged into the chimney. But whatever may be the influence of these conditions in regard to evaporative effect produced, they do not in any degree affect the foregoing considerations as to the maximum evaporative capabilities of the carbon and hydrogen of fuel when burnt in the manner stated, with a supply of air just twice as great as the quantity requisite for their conversion into carbonic acid gas and water vapour.

From these considerations it will be evident that in the combustion of fuel, under ordinary conditions, there is always a great waste of heat actually generated and available. The total waste is considerably greater in the combustion of hydrogen than it is in the combustion of carbon, amounting in the one case to 32·6 per cent., and in the other to 24 per cent. of the total heat of combustion, but still the evaporative efficacy of hydrogen is nearly four times as great as that of carbon.

In the combustion of hydrocarbons under these conditions, whether they be solid, liquid, or gaseous, the total amount of heat generated will be determined by the relative proportions of the carbon and hydrogen they contain. The amount of hydrogen in such substances generally ranges from one-seventh to one-fourth by weight, and for such limits the corresponding amounts of heat generated by their combustion, and their theoretical evaporative power would be as follows:—

Hydro-carbon burnt.	Carbon.	Hydro-gen.	Total heat of combustion.	Equivalent evaporation of water.	
				at 212°	at 60°
lb.	lb.	lbs.	Heat units.	lbs.	
1	·86		× 14,500 = 12,470		
		·14	× 62,032 = 8,684		
			21,154	21·9	18·8
1	·75		× 14,500 = 10,775		
		·25	× 62,032 = 15,508		
			26,283	27·1	23·3

It must be remembered that these results are above the truth, for this calculation does not take into account the quantity of heat expended in effecting the decomposition of the hydrocarbon, *i.e.*, the separation of the carbon from the hydrogen, nor does it make allowance for the circumstance that the quantities of heat calculated as being generated by the hydrogen, are calculated according to the heat-producing power of *gaseous* hydrogen. The results given above, as expressing the theoretical evaporative powers of these hydrocarbons, are therefore too high by an amount corresponding to the heat requisite to decompose the hydrocarbons and to convert the hydrogen from the *liquid* state it has in the hydrocarbons, to the gaseous state it has in the vapour resulting from their combustion.

The difference between the theoretical evaporative power of hydrocarbons comprised within these limits of composition, and their evaporative efficacy, will be determined by the relative proportions of carbon and hydrogen they contain, just in the same manner as shown already, so far as relates merely to the mode in which the heat generated is disposed of amongst the combustion products constituting the furnace gas resulting from their combustion. And it is here necessary to notice another circumstance of considerable importance as regards the advantageous application of fuel, and especially hydrocarbon fuel.

The following tabular statement will show the manner in which the heat that is consumed in producing a chimney draught, is distributed among the combustion products constituting the furnace gas:—

COMBUSTION OF CARBON.

	Furnace gas from 1 lb. carbon.	Quantities of heat in furnace gas.	Equivalent evaporation of water at 212° Fahr.
	lbs.	Heat units.	lbs.
Carbonic acid gas	3·67	600° × ·8 = 480	.5
Nitrogen gas ..	8·94	600° × 2·2 = 1,320	1·4
Surplus air	11·61	600° × 2·8 = 1,680	1·7
	24·22	3,480	3.6

It will be seen from this table that while the total waste of heat in the furnace gas from the combustion of 1 pound of carbon, is equivalent to 3·6 pounds of steam, more than one-half of that heat is consumed in raising the temperature of the surplus air supplied for diluting the combustion product in the furnace. Consequently, any arrangement by which this surplus supply of air could be dispensed with, and combustion maintained at the same rate, would have the effect of reducing the waste of heat to the extent of 50 per cent., and economising the heat generated by the carbon of the fuel to the extent of nearly 12 per cent. Herein consists the advantage gained by blowing the air into a furnace, instead of drawing it in by means of a chimney; for in that case the supply of air may be reduced to just enough to support combustion, and at the same time the temperature of the furnace gas may be so far reduced, either within the flues or tubes of the boiler, or in a feed water heater, as to render the greater part of the heat contained in it effective for production of steam.

The possibility of economising, in this way, the heat generated by combustion of carbon is by no means unimportant; but it is of far greater importance as regards the heat generated by combustion of hydrogen; for in that case the total waste of heat arising from the discharge of the furnace gas at 600° Fah. above the temperature of the air supply is equivalent to about 12 pounds of steam per pound of hydrogen burnt, and nearly one-half of this waste heat is consumed in heating the surplus air supply.

Therefore by dispensing with this surplus air, and cooling the furnace gas in a feed-water heater, a saving of something like one-fourth of the total available heat might be effected. A further advantage would also result from the increased temperature of combustion, viz., 4,692° Fah. for carbon, and 4,922° Fah. for hydrogen, and the consequent more ready transmission of heat from the combustion product to the water in the boiler.

Combustion of Hydrogen.

	Furnace gas from 1 lb. hydrogen.	Quantities of heat in furnace gas.	Equivalent evaporation of water at 212° Fahr.
	lbs.	Heat units.	lbs.
Water vapour..	9·00	600° × 4·3 = 2,580	2·7
Nitrogen gas ..	26·78	600° × 6·6 = 3,960	4·1
Surplus air....	34·78	600° × 8·3 = 4,980	5·1
	70·56	11,520	11·9
		Latent heat of water vapour.. 8,695	9·0
		20,215	20·9

The combustion of the carbon and hydrogen of fuel presents another point of difference, which is important as regards the extent to which the available heat is, under ordinary conditions, capable of being rendered effective in producing steam. This difference is due to the presence of water vapour in the furnace gas, resulting from the combustion of hydrogen. As a consequence of this circumstance a large amount of heat is absorbed and rendered ineffective for producing steam. From the foregoing table, representing the disposition of heat amongst the furnace gas, it will be seen that every pound of water-vapour in the furnace gas corresponds to a waste of heat sufficient to produce rather more than $1\frac{1}{4}$ pound of steam; and hence it will be evident how great is the disadvantage resulting from the presence of water in the furnace gas, whether originating from hydrogen burnt or from damp fuel or otherwise.

The volumes of the air supply and combustion products for the extreme cases of carbon and hydrogen are as follow:—

	Air supply at 60° F.			Combustion products at 660° F.	
	Pound.	Pounds	Cubic feet.	Pounds.	Cubic feet.
Carbon ..	1	24	320	25	630
Hydrogen .	1	69	960	70	2,044

In the combustion of carbon there is no expansion of volume in the combustion product, except that due to the heat generated, which would render the volume at the temperature of combustion (2,522° Fah.) rather more than six times that of the air supplied. By the transfer of heat to the boiler, to such an extent as to reduce the temperatnre to 660° Fah., the volume would be reduced again to about 630 cubic feet per pound of carbon burnt.

In the combustion of hydrogen the supply of air required is about three times as large as that required in the combustion of an equal weight of carbon. There is also an expansion of the combustion products, independent of the heat generated, and amounting to one-half the normal volume of the hydrogen burnt. The expansion due to heat is also greater than in the combustion of carbon, on account of the greater amount of heat generated, so that the volume of the furnace gas at the temperature of combustion (2,791° Fah.) would be about six and a-half times that of the air supplied, and the volume of gas discharged into the chimney would be about $3\frac{1}{2}$ times as great as in the combustion of an equal weight of carbon. This larger quantity of gas will, however, contain nearly four times as much effective heat as that resulting from the combustion of an equal weight of carbon, and its temperature will be about 270° higher, so that in this respect the use of fuel containing a large amount of hydrogen, provided it can be perfectly and readily burnt, presents an advantage as compared with fuel consisting almost entirely of carbon. Rather more than one-fourth of a pound of hydrogen would give as much effective heat as one pound of carbon with a somewhat smaller volume of combustion products. The extent to which this advantage affects the value or efficiency of fuel will, of course, depend on the amount of hydrogen it contains. Since no hydro-carbon available as fuel contains more than 15 per cent. of hydrogen, the actual evaporative efficacy of such a material, when used under the ordinary conditions, cannot, at the utmost, be more than about 40 per cent. greater than that of an equal weight of carbon. This, assuming it to be perfectly burnt, and the arrangement of boiler flues or tubes, etc., to be favourable for the transfer of heat, is the maximum effect to be looked for according to the data already given.

The amount of hydrogen in petroleum is probably larger than in any of the other hydro-carbons proposed to be used as fuel, and that contains, on the average, about 13 per cent. In coal and shale oil the amount of hydrogen is less. Consequently, the evaporative efficacy of these materials, as compared with carbon, would not reach the above limit of 40 per cent. in excess. The ratio between these materials and ordinarily good coal is much about the same in regard to evaporative efficacy, since the hydrogen contained in coal compensates for the oxygen and ash it contains, unless the amount of these is very considerable.

The tables in next page show the relation between the total heat of combustion and the available heat of hydro-carbons, containing respectively 14 and 25 per cent. of hydrogen, as the amounts of heat consumed in the furnace gas, and the mode in which it is disposed of.

I am not aware of any liquid hydrocarbon applicable as fuel, which contains so much as 25 per cent. of hydrogen, so that an evaporative effect of about 16 pounds of steam per pound of hydrocarbon burnt must be regarded as the maximum result to be attained with such material used as fuel. By burning these hydrocarbons with only just enough air for combustion, or half the quantities assumed to be supplied in the above estimations, the effect capable of being realised would be from 13 to 14 per cent. greater than in the case stated above, or about 18 pounds of steam per pound of hydrocarbon containing 14 to 15 per cent. of hydrogen.

The plan of using liquid fuel, which so far as I am aware has proved the most advantageous, is one which does, to some extent at any rate, secure the advantage to be gained by forcing air into the furnace. According to this plan the oil is supplied to the furnace through a small pipe, together with a jet of high pressure steam, by which it is converted into spray, much in the same manner as, in the toy known as the perfume vaporiser, a liquid is blown out of a bottle by a current of air. The steam jet at the same time induces a current of air which mixes with the oil spray and supports its combustion. This is the arrangement used by Messrs. Field and Aydon, and it appears to work exceedingly well, effecting a very perfect combustion of the oil. The oil I have seen used in this way was the dead oil, or creosote oil, which is a refuse product in the refining of gas tar. It possesses characters which render it much preferable to petroleum or to the oil obtained by distilling coal at a low heat for use as liquid fuel. In the first place, its density being greater than that of water—the gallon weighing about 12 pounds—it takes less space for stowage than petroleum or coal oil, the gallon of which weighs only from 8 to $8\frac{1}{2}$ pounds. For the same reason it would not be so dangerous as the lighter oils in case of accident; for instead of floating on the surface of water and burning, it would sink harmlessly. Again, its very high boiling point, approaching to a red heat, and the great density of its vapour as compared with that of petroleum or coal oil, are great advantages as regards risk of explosion in consequence of the oil vapour becoming mixed with air and then catching fire. This could hardly take place with the dead oil, except at a very high temperature, while petroleum readily gives off vapour to the air at a moderate degree of heat.

One pound of hydrocarbon, containing 14 per cent. of hydrogen, yields about 31 pounds of furnace gas, consisting of —

	Furnace gas.	Quantities of heat in furnace gas.	Equivalent evaporation of water. at 212°	at 60°
	lbs.	Heat units.	lbs.	lbs.
Carbonic acid gas ..	3·16	411		
Water vapour	1·26	359		
Nitrogen gas	11·45	1,683		
Surplus air	14·37	2,124	2·2	
	30·74	4,577	4·8	
Total heat of combustion		21,154		
Latent heat of water vapour ..		1,217	1·3	
Available heat		19,937		
Waste heat of furnace gas		4,577	4·8	
Effective heat		15,360	15·8	13·6
Theoretical evaporative power..		..	21·9	

Relative evaporative efficacy as compared with carbon or coal = 1 } 1·39

One pound of hydrocarbon, containing 25 per cent. of hydrogen, yields about 36 pounds of furnace gas, containing—

	Quantities.	Quantities of heat in furnace gas.	Equivalent evaporation of water. at 212°	at 60°
	lbs.	Heat units.	lbs.	lbs.
Carbonic acid gas ..	2·75	358		
Water vapour	2·25	641		
Nitrogen gas	13·39	1,968		
Surplus air	17·39	2,483	2.6	
	35·78	5,450	5·6	
Total heat of combustion		26,283		
Latent heat of vapour		2,174	2·2	
Available heat		24,109		
Waste heat of furnace gas		5,450	5·6	
Effective heat		18,659	19·3	16·6
Theoretical evaporative power..		..	27·1	

Relative evaporative efficacy as compared with carbon or coal = 1 } 1·69

The use of this oil as fuel presents great advantages for gas tar distillers, with whom it is a troublesome waste product. If it should come into demand as steam fuel its value would of course rise above that of coal, to an extent proportionate to its greater efficacy and any other advantages resulting from its application as steam fuel. Such an application might therefore be a great advantage to gas companies.

Unfortunately the quantity of this oil which is available is very small as compared with the requirements of steam navigation, probably not amounting to 100,000 tons a year in the whole country, and therefore its application must be very limited.

In order now to arrive at some estimate of the advantage to be gained in a steam vessel, either in point of weight to be carried, or space occupied by liquid fuel as compared with coal, it is evident that 100 tons of petroleum, or coal oil, would do the work of about 140 tons of good coal. But as coal is rarely burnt in such a way as to be rendered useful to its full capability, and as there is always a considerable waste in the shape of dust and cinders, which would not be the case with liquid fuel, a further allowance must be made for this. Assuming that one-fifth of the coal is wasted in this way, then the equivalent of 100 tons of oil would be 175 tons of coal, for taking the density of the oil as ·850, it would occupy about the same space as an equal weight of coals, or at the rate of about 53 pounds per cubic foot. This difference would enable a vessel capable of carrying coal for twelve days' steaming, to carry oil for twenty-one days. In burning this oil there would be a saving of labour in stoking, and as it would not give any ashes, a great deal of trouble would be saved in that way.

These results differ widely from the statements which have been made in reference to the relative efficiency of oil and coal, according to which it has been represented that one ton of oil was equal to from four to five tons of coal,* and that in regard to stowage room the saving was "more than nine-tenths in bulk"!† It is true that those who have propounded these views have not arrived at them by a consideration of the data I have above referred to, and if I may judge from remarks lately made at the meeting of the Institute of Naval Architects‡ they would appear to deny the applicability of those data for determining the question between coal and oil as fuel. Such a denial, however, would be of little account if it be not supported by adequate evidence of results, such as those which have been so much dwelt upon, being really obtainable; and although this subject has now been some years before the public, I am not aware of any evidence having yet been brought forward, such as would call for, or justify the abandonment of those well-established principles by which the heating power and efficacy of fuel is determined, as above stated. §

The results of the experiments made at Woolwich, under the superintendence of Mr. Trickett, the Engineer in Chief of the Dockyard, give, as the highest evaporative effect obtained with petroleum, 11·63 pounds of water converted into steam per pound of oil burnt. In this case, however, the combustion was imperfect. But in the most successful trials with coal oil and shale oil, when very little smoke was given off, the evaporative effect was about 18 pounds of steam produced per pound of oil burnt. In this case some deduction required to be made for the steam applied as a blast to the fire, but the amount was not ascertained. This result was also obtained under peculiarly favourable circumstances as regards the proportion of heating surface of the boiler to the rate of evaporation.

In regard to the supply of material capable of being used as liquid fuel, it is necessary to make a few remarks. First, as regards petroleum, I imagine it is now generally acknowledged that this material in its natural state is not well adapted for the purpose. In that state it contains a large amount of very volatile hydrocarbon, which, even at the ordinary temperature, vaporises by contact with air, and the mixture of this vapour with air

* See *Journal of the Royal United Service Institution*, ix. 66. "Petroleum as Steam Fuel," by Capt. J. H. Selwyn, R.N.; also C. J. Richardson, p. 70.

† Ibid, p. 69.

‡ See *Engineer*, 10th April, 1868, p. 257.

§ Since writing this paper I have learnt that the same subject was discussed by Professor W. J. M. Rankine, at the United Service Institution, about a year ago, and I have great pleasure in referring to the opinions of such an authority in confirmation of the views I have expressed in regard to "Liquid Fuel."—["On the Economy of Fuel, comprising mineral oils." *Journal of the United Service Institution*, xi., 218.] The very lucid and exhaustive exposition, given by Professor Rankine, of the conditions which determine the theoretical evaporative power of fuel ought to have been sufficient to prevent any continuance of misconceptions as to the possibility that the evaporative effects realized with fuel can exceed or even equal the extreme calculated power it is capable of producing.

is explosive. At the temperature of a steam vessel's stoke-hole this vaporisation would take place more readily, and if there were any leakage in the supply pipes or tanks, disastrous consequences might ensue. In order to remove this objection to the use of petroleum as liquid fuel, the more volatile portion of it must be separated by distillation, and that operation, when carried far enough to render the oil fit for use with safety, would reduce the quantity to about one-third.

Another objection to petroleum in its natural state is its bulkiness, the gallon weighing only about 8 pounds. This is to some extent removed by the distillation, and by the reduction of the quantity to one-third an oil is obtained which weighs about 8½ pounds per gallon.

According to the latest returns, the total production of petroleum in America—which is out of all proportion the most abundant source of this material—amounts to about 360,0(0 tons a year. It would be mere speculation to offer any opinion as to whether this rate of production is the maximum which is attainable, or as to the time it may continue; but the prevailing impression is that the sources from which this supply originates are subterranean accumulations, and, therefore, not to be depended on beyond a certain limit. The experience of oil winning in America has confirmed this view, for it has been found that the wells which were at first what are termed "flowing wells," *i.e.*, yielding their oil spontaneously, have gradually ceased to flow; and that after pumping has been resorted to for bringing the oil to the surface, even that means gradually declined in its effect. It would, therefore, be unwise to rely upon the supply of petroleum as affording material for fuel. And then, if we consider the vast consumption of coal for the purpose of steam navigation —amounting, I believe, to not less than 10,000,000 tons a year in steam vessels belonging to this country alone, it will be seen that the production of petroleum— gigantic as it is in relation to the use to which it has been applied—is insignificant when compared with the requirements of steam navigation for fuel; that, in fact, the total production does not amount to 5 per cent. of the fuel consumed in the steam vessels of this country.

The possibility of obtaining an oil analogous to petroleum by distilling certain kinds of coal and some varieties of bituminous shale, constitutes another source of liquid fuel, and one which I consider to be far more important, for this country at any rate, than petroleum is. The material obtained from this source, and commonly known as crude paraffin oil, requires to be submitted to the same operation as petroleum, in order to remove the more volatile portion, and obtain an oil suitable for use as liquid fuel, but it would have the advantage of yielding rather a larger amount of such oil than petroleum does. To what extent the production of this oil might be developed as a source of supply for steam navigation it would be almost impossible to form any approximative idea at present. But I may state in regard to this point, that owing to the low price at which petroleum is now imported from America, the coal and shale oil works of this country have been almost entirely stopped, because of their inability to manufacture oil for burning at such a price as to compete with the American product. Circumstances which it would be out of place to enter into here, induce me to believe that if the use of liquid fuel were introduced to any extent into practice, it would be a very great advantage to the oil manufacturers of this country, and would be a means of enabling them to meet successfully the competition of the American oil used for burning in lamps. I have already spoken of the supply of "dead oil," furnished by the rectification of coal tar, and need here only remark again that the quantity is very small. This is certainly the most suitable material for use as liquid fuel which I am acquainted with, and its excellence in this respect induces me to mention another possible source of a similar material, viz., the distillation of "slack," or the waste coal dust, which accumulates at the mouth of a coal pit. It is quite possible that by such means a quantity of oil, similar to that resulting from the rectification of gas tar, might be obtained, and at the same time the slack itself might be converted into a useful fuel.

There is also in the Island of Trinidad a vast deposit of bitumen, which has repeatedly been an object of passing interest on account of attempts to render it in some way useful. Unfortunately, most of those attempts have hitherto failed; but if liquid fuel should become an article in demand, I think there may be good days still in the future for Trinidad bitumen, for it has the peculiarity of yielding by distillation, about 30 per cent. of a thick, heavy oil, approximating very closely to the "dead oil" of the gas tar refiner. This circumstance, which has hitherto been the disadvantage of the Trinidad bitumen, might then become its chief recommendation, and according to all accounts, there is abundance of it, and the getting of it is not attended with difficulty.

The relative cost of coal and oil is to some extent still an open question. If it should be found advantageous to use oil as fuel for steam vessels it is probable that neither crude petroleum nor paraffin oil as obtained by distilling coal or shale would be the most suitable for the purpose, and that it would be advisable to separate from either of those materials the more volatile portions, which are applicable for burning in lamps. The less volatile portion, both of petroleum and of shale oil, amounting in the former to about 30 per cent., and in the latter to about 40 per cent., would be for several reasons best adapted for use as fuel. It is not so much in demand as the oil used for lamps, and being less volatile it could be stowed with greater safety. But I doubt much whether this oil could be shipped for less than £5 per ton. If that opinion is correct, according to the comparative estimate already made between coal and oil, the cost of the latter would be about three times as much as that of coal. That there may be circumstances under which the advantages to be gained by the use of oil as fuel would altogether outweigh any considerations as to this or even a greater rate of cost, it does not require any great penetration to perceive; but it appears to me equally evident that if those advantages are to be attained only at such a cost, the use of oil as fuel for steam vessels must in any case be restricted to exceptional cases, in which cost is comparatively a matter of secondary importance, and that it cannot be regarded as likely either to revolutionise steam navigation in general, or to call for a total reconstruction of our navy.

At this point, however, the consideration of the subject reaches a stage where it is more the province of the merchant and of the naval engineer to deal with it, and to determine the balance between the greater efficacy of this material as fuel, and the greater cost which its application would involve. I therefore leave it here for those more competent than myself to discuss these points, with the hope that the attempt I have made to elucidate the subject, so far as I am able, may be found of some utility in its further development.

I cannot, however, conclude this paper without taking the opportunity of expressing my opinion that the mode in which this subject has hitherto been dealt with, illustrates in a most striking manner, the want which is now somewhat vaguely felt of what is termed "technical education," by which I understand a means, not merely of making those whose business is of a practical character better acquainted with the principles of science and the laws of nature than is generally the case in this country, but also of educating the cultivators of science in a knowledge of the requirements of art, and of the conditions under which science can be made serviceable to practice. If such a closer alliance between science and practice were achieved, I believe it would be found of mutual advantage, and then I apprehend we should soon cease to hear anything more of that fancied antagonism between the two which is the most effectual barrier to progress, and deserves only to be regarded as an indication of ignorance or bigotry.

DISCUSSION.

Mr. Warriner said for the last three years he had expended his time, his money, and that of his friends in endeavouring to work out the problem of how best to consume liquid fuel, having been led to turn his attention to the subject from observing the waste of fuel in cooking. When attention was drawn by Sir William Armstrong to the probable exhaustion of our coal-fields, his thoughts were still more strongly directed to the question of liquid fuel, and he had visited almost every part of the three kingdoms, and had taken notice of the localities where it seemed probable that oils such as had been mentioned would be found; although he did not mean to suggest that these natural oils were so suitable for the purpose under discussion as creasote or dead oil. He believed these oils were to be found in large quantities in England, Ireland, and Scotland, and in all parts of Europe, and that they could be produced at a price much less than £5 per ton, in fact at very little above the cost per ton of coal. He was the patentee of an invention for the use of petroleum as fuel, and there were 38 patents now taken out for the same thing, and 62 more for processes pertaining to it. The petroleum had been discovered quite accidentally at Mold, in Flintshire, and he could name many places in England where he believed it would be obtained by simply boring. The writer of the paper seemed to object to the use of this oil as fuel, but it had been tried in America, and although the results of Mr. Richardson's experiments at Woolwich were failures, they were such failures as showed that with proper means success might be expected. He considered it desirable that the Society of Arts should assist in these matters, and suggested the offering of premiums for the best method of burning these oils. There was one liquid which Dr. Paul had not mentioned as fuel, and that was water. At the present moment there were locomotives in New York running by means of decomposed water as fuel, and, knowing what had been accomplished in the smelting of iron in common furnaces with the aid of superheated steam, he had tried the same thing with petroleum oil, or rather creasote, and very good results had been obtained. At this very time he was melting scrap and pig-iron in a very short time by these means, and getting 14 heats per day in a cupola which before only yielded 6, and this without any great expense. There were 150,000 men employed in this country in coal mining, many of whom did not, during a great part of the year, see the light more than once a week, and they were the most immoral and illiterate of the working classes, but if the consumption of coal were not kept up, many of these men would be employed in other ways to the benefit of themselves and society.

Mr. Blackie begged leave to deny that coal miners were the most illiterate and immoral class of men. He had known them many years, and some of them were very well educated indeed for their station.

Mr. Lambert said he had been a coal owner for many years, and there was not a more moral, intelligent, and cleanly set of men in the world than the colliers.

Captain Selwyn, R.N., said he had come fresh from the study of this subject, as he had been all the afternoon driving a boiler with creasote which had been built for the Admiralty under his superintendence. He had expected to find Dr. Paul a formidable enemy to the burning of liquid fuel; for hitherto chemists, with the exception of Professor Rankine, had rather discouraged its use, and had even refused to receive facts which did not happen to agree with their own theories. It was a fact that a boiler of 35 horse-power, of the ordinary Cornish type, with Galloway tubes, had been since Christmas at work at Hackney with oil. The consumption was 230 gallons per day, and 23 lbs. of water at 35 lbs. pressure, were evaporated for every pound of fuel used. That fact could not be got over. Naphthaline was the fuel used, and it was melted in tanks by the waste steam, and then run into an ordinary apparatus for burning. In speaking of the experiments at Woolwich, he would remark that if any chemist, engineer, or practical person had seen the process adopted there for burning liquid fuel, he would have come to the conclusion that one more wasteful, or less likely to yield good results could not have been employed; and if with that process 18 lbs. of water were evaporated for each pound of fuel consumed, he considered the result very encouraging. The data to go by were not what could theoretically be done, but what was practically effected in steam boilers; and this, with coal, had hitherto been about 7lbs. of water evaporated per lb. of fuel; 10lbs., and even 11lbs. had been evaporated in experimental boilers, but never in a run across the Atlantic. Therefore, even 18lbs. was a great increase of power; and they must recollect that if this were once obtained it could be relied upon, as there was no deposit of any kind to foul the boiler or tubes, no smoke, or residual products of any kind. Mr. Richardson, it was true, had an enormous deposit of carbon, but that was because he did not know how to apportion air to the supply. Even 18lbs. of water evaporated, however, was a much greater advance than Dr. Paul had given them credit for, being about 2½ times the result obtained from coal, but if they got 23lbs. evaporated at a pressure of 35lbs., which was equivalent to 27 at atmospheric pressure (though he never claimed more than 23lbs.), they had obtained a most valuable result. Naval steamers carried coals for ten days, not more; but if instead of 7lbs. of water evaporated per lb. they had 23lbs., it was evident they could be provided with fuel for 30 days, and this would be worth attainment, whatever might be the price of the fuel. As a naval officer, he could state that no price could be too high to pay for the power of fuelling a war steamer for 30 days instead of 10. It might be the means of averting a great national disaster. Nor would the reconstruction of the navy be required. With the expenditure of £5 for an apparatus, which any engineer on board ship could put up, he could convert any ordinary boiler into one which would burn either wood, coal, or oil, and that in two days after receiving the order. A great advantage would result in stowage. Coals could not be pumped up; they had to be trimmed in coal-bunkers, which, as they were emptied, could not be filled with ballast, and the result was, that when a vessel left port in such trim as to obtain the best results from her particular motion, a change must immediately take place in the trim; the change took place irregularly, and they never knew whether they were doing what they ought. With oil, particularly heavy oil, which alone he advocated, as all possibility of evaporation could be prevented by keeping water constantly over it, and if any ran out it sank below the water in the hold—these difficulties were avoided, for, as the oil was consumed, water could take its place as ballast, and thus the trim would be preserved. If they considered the commercial part of the question it amounted to this, that an ordinary vessel on the Havre line to America, carrying cargo, would save about £3,000 per round trip by the use of creasote instead of coal, allowing it to evaporate only 2½ times as much water per lb. as the latter. There would be a saving in stokers' wages and victuals, and of course in cargo room. That was reckoning the price of the fuel the same as at present; of course the price would rise with the demand, but he trusted to competition in such a case to increase the supply. It would be folly to take the production of petroleum in America as any measure of that in the world; it was probably much more widely spread than coal, and it was evident it existed in immense quantities, because in many localities it actually made its way to the surface in flowing wells, by the pressure of the gas upon it. If they happened to bore down at the top of such a cavity, for some time nothing but gas would be produced, and in some places a boring would produce salt or impure water, but when that had flowed

off there was either a flowing or pumping well, according to the part which was struck. This deposit of oil had been in existence since the days of the Maccabees, as he had formerly shown by a quotation from the Bible, and it had been constantly used by large tribes in all ages. He estimated the production of kerosene at about 300 pounds, or thirty-two gallons per ton of coal distilled, but in this country creasote was a waste product, the price of which was, until very lately, three farthings a gallon, but it had now gone up to one penny, but if it went to sixpence it would not frighten them. He was quite sure the oil interest in Flintshire would revive under the excitement consequent on a large demand for oil as fuel, and, in fact, he was somewhat surprised in going through the paper to find that the author had set up so many giants for the mere sake of knocking them down again. Amongst them was the idea that nobody but himself had studied the chemical theory of the subject, and that those who had been engaged upon it had been working in the dark. This was not the case, for Professor Rankine, in a paper read by him before the United Service Institution, had given to all inclined to study it the complete alphabet of the subject. They knew perfectly well what to do and how to do it, and, what was more, they were doing it. He had seen how to do it for a long time past, and he was now doing it for the Government, in the first instance on a small scale, for a steam launch, which answered admirably. He was next about to apply the principle to an evaporative boiler, the same as employed by Mr. Richardson, and he hoped to show that instead of 18lbs. of water he should evaporate 23 for every lb. of fuel, but if he could not, it would only be because he had got a bad type of boiler. They must not forget that for years they had been trying to obtain a good type of boiler for coal, and had not yet decided upon the best, and therefore it could not be expected that they should all at once hit upon perfection for burning oil. In the latter case, however, there was no necessity for the waste draught which was adverted to in the paper, which made a considerable saving, and as there was no deposit, the tubes might be made considerably smaller, so as to get a much greater heating surface than could be obtained with coal. He thought Dr. Paul had laid too much stress upon the theoretical data to be obtained from carbon, which never had been and never could be realized in practice. The conflict between the stoker's work and the chemist's theory had only been successfully reconciled by the chairman in regenerative furnaces, and that was done in a manner which was not quite applicable to the case of marine boilers. Any one who could enable them to do away with the nuisance of getting up ashes and storing coal, and being annoyed with smoke, would, he was convinced, find his efforts very readily appreciated.

Mr. Carnegie had listened with much pleasure to the glowing details of a plan by which weight would be saved and speed gained in steam vessels; but when he found that only two and a-half or three times the result obtained from coal could be looked for from petroleum, and that the author of the paper estimated its cost at £5 a ton, he thought the advantage dwindled away altogether. He had no object but that of getting information as to how to reduce the cost of carrying a certain amount of weight in a steam vessel; but he did not yet see how, on the figures given them, this was to be accomplished. Three tons of coal, free on board at Havre, would cost something like 60s., and if one-third the amount of liquid fuel cost the same, there would not be much gain except in space, which certainly was an important item. However, he could not see how a saving of £3,000 a trip could be effected, because he believed—putting aside any idea of vessels from Havre, under a French flag, commanding exceptionally high freight—on a vessel of 1,000 tons, the whole profit of a voyage across the Atlantic would not exceed £3,000. He was not an engineer, but spoke only as a commercial man, and, from his point of view, he did not see that any great saving had yet been made out. With regard to the possible exhaustion of coal in England, he would remark that there was coal all over the world, and if they could get coal on the coast of the Black Sea costing much less than English, why should they continue to export coal to Turkey? Then, again, Austrian coal, which two or three years ago could not be obtained on the Lower Danube, was now produced from the mines of Oravicza in large quantities. 4,000 tons were supplied from those mines last year, and it drove the English completely out of the market. If they were going to have the Suez Canal opened, and a great development of trade with the East, he did not doubt that the Austrian and Turkish coal—and in time, the Russian—would find its way to India, and that in a commercial calculation therefore the exhaustion of English coal would not be taken into account.

Mr. C. F. T. Young said the oil which would be used for fuel he was now getting at the rate of 17s. per ton instead of £5, and if the price were put at £1 that would be an ample margin, and would show an immense saving by the use of oil. Besides that, there was a great saving in convenience, and in enabling all the products of combustion to be used with greater effect from the non-deposition of any dirty matter in the tubes or heating surfaces. Another advantage was that the fire was instantaneously under control. In an ordinary furnace you had either to draw the fire or damp it down, and in either case there was a lapse of some minutes before the effects of the heat were checked from acting on the boiler, but with oil the effect was immediate, both in turning off and on. He was now preparing a boiler of between 200 and 300-horse power, with which oil was to be used. He intended to use dead oil, the commonest which he could get, and this, after all, was best suited for the purpose. He considered the use on board ship of any oil which gave off vapour would be most dangerous and reprehensible, and ought not to be permitted. The author of the paper had remarked on the small quantity available; but that showed nothing, because a demand always created a supply. He believed the number of gallons which could be obtained from a ton of coal would average fifty or sixty, which, at 10 lbs. weight a gallon, would be about one-fourth of the weight of coal. If, then, the same weight of liquid fuel did three times the duty, and there were many other advantages, it was a question whether it would not even pay to destructively distil the coal for the sake of the oil, rather than use it in its raw state. A friend had sent him a slip from an American paper, stating that a steamship was being tried there burning liquid fuel; it did not state the arrangement, but he believed there was a kind of retort, by which the oil was first converted into gas and then burnt. He took his figures as to the amount of oil to be obtained from coal from Mr. Gesner's book, which gave the largest quantity at about 120 gallons per ton, the average being about 60 gallons.

Mr. Phillips thought if fuel could be obtained at 1d. a gallon, weighing 12 lbs. to the gallon, and doing three times the duty per pound that coal would, the question was virtually decided.

Captain Selwyn said the specific gravity of the oil he used was a very little over that of salt water.

Mr. Rippingale here introduced an experiment, having for its object to ascertain the exploding temperature of mineral oils. The peculiarity over the ordinary method was that the action took place in a closed vessel, into which a thermometer was inserted, an electric spark causing the explosion. The advantage claimed for this method of testing was, that it was much more reliable than the ordinary one in open vessels. The specimen of oil exhibited exploded at 90°.

Mr. Young said he understood that before the Select Committee on Fire Protection, some oils were found to explode at 80°, and some even as low as 60°, and that the proposal made was that none should be allowed to be sold which exploded at less than 120°. In the case of

creasote, all the volatile spirit had been extracted, but it did not pay, as a rule, to do this, and that was why the common oil was so dangerous. He believed there was only one firm in Scotland who extracted the spirit properly. He had actually seen on board a ship in the port of London casks of raw oil smelling very strong of spirit put against the bulk-head, close to the boiler, and had told the men how dangerous it was, which seemed quite to surprise them.

Captain Selwyn would like to know the proportion of atmospheric air required to form an explosive mixture with the volatile spirit from petroleum?

Mr. Rippingale said the proportion was about the same as in the case of coal gas—about one-sixth part in volume.

The Chairman said that nine parts of air and one of gas was the lowest proportion in which explosion occurred.

Dr. Paul, in reference to the remarks of Mr. Warriner, said he did not profess to be much versed in cooking, but as that was managed entirely by means of heat, he had no doubt, from the way in which fuel was often wasted, that there was immense scope for improvement in that direction. He was not prepared to share the opinions which the same gentleman had expressed as to the value of water as fuel; setting the Thames on fire had been often talked of, but was still, he believed, a long way from being accomplished. There was a great deal of misconception as to the influence of steam in the use of fuel, and many erroneous opinions were entertained. Similar opinions had been broached some time ago with regard to superheated steam, and though these ideas had to a great extent died away, the same fallacy seemed to be cropping up again in a new form. In the burning of a given weight of any elementary substance whatever, the effect of combustion was to produce a certain amount of power, and that effect was represented partly by the heat capable of effecting the evaporation of a certain weight of water, and partly by the conversion of the substance burnt into gas. The power thus produced was a perfectly definite and constant quantity, and for separating the constituents of the product of combustion, an expenditure of force was requisite exactly equal to that produced by the combustion. Consequently, there was no advantage gained. For instance, in burning a pound of hydrogen a certain definite amount of heat was generated, but if they first took nine pounds of water, decomposed it, and got the one pound of hydrogen out of it, they simply expended in obtaining that hydrogen the same amount of heat which might afterwards be got out of it again by combustion. That principle was simple enough, and he was surprised at any one with any pretensions to an opinion upon the subject talking of the benefit to be obtained by the decomposition of water. Captain Selwyn had entirely mistaken him in supposing that he was at all an opponent of the use of liquid fuel, or had any objection to the experiments which any one might think it right to make in that direction. He considered the subject well worthy of attention, and that it would well repay the labour of any one who would investigate it in a rational manner; but when he heard statements made to the effect that oil would do five times as much work as its own weight of coal, he must enter his protest against them. He had always thought it highly desirable that proper experimental data should be procured. Those necessary data were very simple. They required to know the weight of water evaporated in a given time, and the temperature at which it entered the boiler, and the weight of oil burned. But they wanted those three facts with absolute accuracy, and in the determination of them there was great possibility of errors arising which would materially affect the result. He believed Captain Selwyn and his coadjutors in these experiments had fallen into serious errors, and had made mistakes in their deductions accordingly. Professor Rankine had been cited, but he was quite sure that gentleman would not allow his authority to be brought forward in support of a statement that one pound of any kind of fuel would evaporate twenty-three pounds of water. In the paper read by him, before the United Service Institution, he distinctly stated that the highest evaporating power was under twenty-two pounds. But that number represented the maximum theoretical evaporating power, which was a very different thing from the duty, and was never arrived at in practice, for, as he had already pointed out, only a portion of the heat actually generated was effective in producing steam, because a considerable quantity was usually wasted in producing the chimney draught. A great portion of heat might be saved, which now went up the chimney, by reducing the volume of air supplied; and a still further saving might be effected by substituting oxygen for air, so as to reduce the products of combustion to the smallest quantity possible. The heat contained in the smoke which escaped from a chimney represented so much steam which had not been produced in the boiler. At the present time it might seem premature to talk of the application of oxygen to burning fuel, but it was by no means impossible. Several methods had been suggested for obtaining oxygen for such purposes, and it was quite feasible that some plan might be discovered for extracting the nitrogen from the air, so that the residuary oxygen might be available for combustion. With regard to the available supply of hydrocarbon oils, he regarded that of American petroleum as the most copious, out of all comparison with any other known, and he had visited and made careful observations of all the petroleum fields in Europe. The continuance of that supply, however, he could not regard as to be depended upon as a source of fuel. He quite agreed with Captain Selwyn that the attempts which were made by Mr. Richardson to obtain greater economy of fuel were the most futile that could be conceived, although he believed Captain Selwyn had not always held that opinion. He believed the direction in which they might most usefully look for an improvement in the economy of fuel was in the consumption of coal in steam vessels. He thought that engineers present would support him in the statement that for each indicated horse power they had, in a certain class of freight steamers, a rate of fuel consumption amounting to from 4 lbs. to $4\frac{1}{2}$ lbs. of coal per hour, and in some cases even more. There was another class of vessels in which the consumption of coal per indicated horse power was not above 2 lbs. or $2\frac{1}{2}$ lbs. of coal per hour; and statements had been made that the same result could be obtained by the consumption of $1\frac{1}{2}$ lb. or even 1 lb. of coal. If a saving in the consumption of coal amounting to the difference between these quantities could be effected, a result would then be realised far in excess of anything which could be expected from the use of liquid fuel, and in regard to steam navigation generally, that, he apprehended, was a far more legitimate and promising field for the exercise of skill and ingenuity than the attempts to introduce liquid fuel. He did not at all wish to detract from the merits of this kind of fuel, and there were no doubt certain exceptional cases in which an increased cost of fuel would be but a secondary consideration, where it might have great advantages, but he did not think it could ever be generally employed. With regard to the statement made as to the quantity of oil which could be obtained from coal, and quoted from Mr. Gesner's book, he might say that that authority was not to be trusted. The average coal in the country would produce perhaps about two gallons of oil per ton; the oil-producing coal formed only a small portion of our coal. Cannel coal was of that character, the very best specimens of which would yield about 60 gallons of oil per ton, while the more anthracitic coal of South Wales would not yield so much as two gallons.

The Chairman said that the discussion had elicited

quite a conflict of opinions, while those held on each side were apparently based on independent facts; but he believed it was not impossible to reconcile many of the statements which were apparently contradictory, by properly discriminating between theoretical and practical results. These two ought to be kept distinctly apart. The practical result would ultimately approach to the theoretical, if all the conditions of the various operations were perfect, but it could never quite attain it; and, unfortunately, in the consumption of solid fuel, the practical results did not nearly approximate to the theoretical ones. He believed that some years hence any engineer who looked at the furnace of one of our present marine boilers would be ashamed of it. The mode of throwing the fuel on a kind of volcano, giving off a large proportion of valuable substance in the form of thick smoke, was very objectionable. As far as he could follow the calculations given, he thought Dr. Paul had rather overstated than otherwise the theoretical evaporating power of liquid fuel as compared with coal. He gave the evaporating power of hydrogen at 64 lbs., which agreed with the statement laid before the United Service Institution by Professor Macquorn Rankine, but there was a correction to be made in that. Professor Rankine gave the evaporating power of hydrogen at 64·2, and of carbon at 16·05, but he considered, in this calculation, the hydrogen as existing in a gaseous state, and the carbon in that of a solid. He made an allowance for the chemical affinity between the hydrogen and carbon when in the form of marsh gas, but he did not allow for the hydro-carbon as being in a liquid condition, in which state it was when in the form of oil. There must be a correction made on that account, though he could not precisely say what it should be. There was another correction to be made with regard to the latent heat of the steam resulting from the combustion of hydrogen, by which, no doubt, the results would be very sensibly modified. However, if they went from theory to practice, they had certainly great allowances to make in favour of the oil. For instance, coal contained not only alkaline matters, but also a great deal of water, which oil did not; then, a certain portion of oxygen was already absorbed by the coal, and there was a great waste by smoke. Further, it was impossible, whilst burning fuel upon a grate, to obtain that regularity of proportion between the air and the material consumed, which was necessary to produce an economical result. All these points were arguments in favour of the liquid fuel. He must say, that he quite agreed with several of the speakers, that *volatile* liquid fuel was totally inapplicable, and would be one of the most dangerous things imaginable on board ship; they must, therefore, consider the question as confined to the use of heavy oils, which might, no doubt, be employed with advantage. They admitted of better stowage than coal, occupied much less bulk, and would save on board ship a great deal of labour, which meant space, of course, as less men would be required. Then there was another great advantage—there was no smoke. This, in the case of men-of-war, was very important, because a fleet of steam vessels at present could be seen while they were many miles below the horizon. For the mercantile marine, however, the question would reduce itself to one of price; and if the oil were £5 a ton, and the coal £1, no doubt the advantage would be in favour of the latter.

Captain Selwyn said he was now using oil at 1d. a gallon, or not quite £1 1s. a ton.

The Chairman said, that so long as the oil could be obtained at anything like the price now mentioned, no doubt it would be a most valuable fuel; but the question was, would the price remain so favourable to the consumer if the demand should increase? Of that he must say he had considerable doubt. If they had to distil the oil specially for the purpose from coal it must be expensive, and they must therefore fall back upon the natural supplies, or those which were incidental to other manufactures, which supplies must necessarily be limited. As to the use of water for burning, he was quite sure that no one acquainted with the subject would attribute any special evaporating power to water itself. Water might be usefully applied sometimes in conveying heat from one place to another, as, for instance, the introduction of a jet of steam under a grate on which anthracite coal was burning produced a gaseous fuel, the heat from which might be readily conveyed to a considerable distance, but as to getting heat out of water it was absolutely impossible. He would conclude by moving a vote of thanks to Dr. Paul, to which he was sure they would feel he was fully entitled for his able and carefully written paper.

The vote of thanks was then passed and acknowledged.

PARIS HORSE SHOW.

The exhibition of *chevaux de service* horses for driving and riding, of the Société Hippique Française, has just closed in the Champs Elysées, and attracted large numbers of visitors. The character of the collection was essentially practical, neither race horses nor hunters were included in the classification; and the ponies, which form class six, were, in fact, all galloways, and not ponies, in the English sense of the word.

There were in all 441 animals exhibited, namely:—Class 1, carriage horses, full $16\frac{1}{2}$ hands high, 64; class 2, ditto, $15\frac{3}{4}$ hands, 207; class 3, ditto, over $14\frac{3}{4}$ hands, 154; class 4, post horses trained in pairs, over $14\frac{3}{4}$ hands, 16; class 5, saddle horses, in two divisions, respectively of $15\frac{3}{4}$ hands and upwards, and between that and 15 hands, 41; and class 6, ponies, under 15 hands, 20. Each class, with the exception of the last, was subdivided into two sections, one for animals of four years, and the other for those of five and six years.

A large majority of the horses were from Normandy; but Vendée and Poitou made a better show than they have ever made before. The exhibition was peculiarly interesting from the fact that it shows the results which have been obtained by the training establishments (écoles de dressage), which have been instituted principally by the Société Hippique, which includes amongst its members the Emperor and Princes, General Fleury, director of the Imperial haras, and many of the wealthiest men in France. The exhibition was, in fact, principally composed of the results of these establishments, for the Ecole of Caen contributes 70 horses; that of Séez, 40, and of St. Maixent, 64. M. Gustave Marion, a breeder, sent 38 horses; but these, and the animals contributed by most of the leading breeders, have been trained in one or other of the above-named establishments.

The prizes offered amount to 59,288 francs (£2,371), and vary in value from 200 to 1,500 francs; additional sums are added when carriage horses are also exhibited as trained saddle horses. There are extraordinary prizes, varying from 1,500 to 3,500 francs, for the most remarkable animals in the four principal classes, and two prizes of honour for the best and second-best stable of not less than five horses of any kind.

The exhibition was extremely well arranged, there being ample space for double the number of horses, and the central portion of the building supplying a capital ride, with a tribune for the judges, and seats and standing room for two or three thousand spectators. Riding horses and carriages of all kinds were exercised during all hours of the day, the interest being increased by a hurdle fence for leaping. The exhibition was to remain open until the fifteenth instant inclusive, the grand day being the fourteenth, when all the horses for which prizes have been awarded were to be exhibited.

In connection with the horse exhibition were a few very elegant carriages with improvements and adaptations; a considerable number of velocipedes, which are very popular in Paris at present, including one for a

party of four persons; stable fittings from English and French houses, chaff cutting, crushing, and other machines; patent horse shoes, and miscellaneous articles. On the whole the exhibition was a thoroughly practical and an important one, and marks great progress.

Fine Arts.

Statue of Palissy the Potter.—The inauguration of a statue of Bernard Palissy is to take place at Saintes, where the famous potter was born, on the 3rd of the coming month of May. The *fête* to be given on the occasion will recall one of the most interesting events in the history of the town, namely, the entry of Charles IX. and Catherine de Medicis, and their visit to Palissy, whom they took with them to Paris, where he was installed in the old Louvre, and executed some remarkable works; and where the remains of his kiln and a number of his moulds were discovered last year.

Manufactures.

Mode of Cleaning Buildings.—M. Nivert, of Paris, has invented an apparatus for cleaning public buildings, houses, and statues very cheaply and expeditiously, and, it is said, very effectually. It consists of a steam generator, with one or more of Giffard's injectors, and a light scaffolding, by which a tube communicating with the apparatus may be raised to any part of the building, so that the water or other cleansing fluid may be projected forcibly against it. It may be employed with water, or water and steam mixed, or silicates may be used if it be desired to preserve the stone from the action of the air. It has been in use in Paris for the last eighteen months, and it is there called *nettoyage normal*. Mr. Nivert, the inventor, recently cleaned a house in Paris sixty mètres long by twenty mètres high in less than three days, at a cost of 1,200 francs. A patent has been secured in England, and the apparatus has been tried with success in London, at the Church of St. Paul's, Covent-garden.

Commerce.

Silk Trade of Lyons.—The following were the imports and exports of silk at Lyons during the month of January, 1868:—

Imports.

	Frs.
Eggs or grains from Japan	1,472,500
" " Italy	46,500
" " British Dominions on Mediterranean	69,750
" " Various other countries	170,500
Total...... Frs.	1,759,250
Cocoons from Italy	167,508
" " England	6,204
" " Greece	607,992
" " Turkey	612,128
" " various other countries	322,608
Total...... Frs.	1,716,440
Raw silk	16,409,250
Thrown silk	7,725,000
Floss silk	3,546,450
Total...... Frs.	27,680,700

In the above items, raw and thrown silk, Italy figures for 9,963,500 frs.

Exports.

	Frs.
Plain stuffs	17,378,998
Worked do.	533,463
Ribbons	4,142,806
Total...... Frs.	22,055,267

Of the plain stuffs 2,533,130 frs. were exported to the United States, and 7,649,669 frs. to England.

Cotton Growing in India.—According to the latest statistics on cotton growing in India, at the end of last year there were in the Madras Presidency 1,361,474 acres under cotton crops, as compared with 1,229,531 acres in 1866. For Indigo, 111,484 acres in 1867, as compared with 80,911 acres in 1866. At Bellary the increase in cotton growing is estimated at 74,368 acres; at Kurnool, 72,499 acres; and at Tinnevelly 12,638 acres.

Colonies.

Manufacture of Salt.—A company has lately been formed at the salt lakes near Cressy, to manufacture salt by natural evaporation. These lakes are about 45 miles from Geelong, and are about 30 miles from the Leigh-road station of the Melbourne and Ballarat Railway. Large quantities of salt have years ago been brought into Geelong and Melbourne from the lakes, and went into general consumption, and the trade gradually progressed from 1844 to 1850, when the gold fields caused its total abandonment. Some years ago about 80 tons were collected for the Ballarat market, since when other annual deposits have been collected and disposed of at Geelong and Ballarat.

Crops in Australia.—The crops, both in Victoria and South Australia, promise unfavourably. Early in the season rust made its appearance and did much damage, whole fields of wheat being mowed down for hay; the oat crops were in many instances quite eaten away. The average yield in South Australia will probably be between 12 and 15 bushels to the acre,; and it is not expected that this return will be exceeded in Victoria.

The Labour Market in Sydney is adequately supplied with mechanics, agricultural servants, gardeners, and general labourers, for which classes there is only a moderate demand. The supply of clerks, grooms, storekeepers, porters, and persons requiring light work, is considerably in excess of present wants. Female servants are in request for town and country. The following are the present rates of wages, with board, lodging, and rations, per annum:—Carpenters and blacksmiths, £50 and £70; rough carpenters, £35 and £40; married farm and domestic servants, £45 and £50; grooms, coachmen, and gardeners, £35 and 40; farm and garden labourers, £26 and £30; female servants, £18 and £26.

Boiling Down Horses.—There appears to be some chance that horses will soon become of a commercial value for boiling down. One of the breeders on the Murrumbidgee has lately experimented upon a fat but otherwise useless horse, as to the profit of boiling down. After the process had been carefully carried out he realised fifteen gallons of pure oil, which he readily sold at 6s. 6d. per gallon. To this is to be added the value of the hide and hair, also the glue from the hoofs and manure from the bone. The idea of using the flesh for food does not appear to have been entertained.

Preservation of Food.—A Brisbane paper says considerable attention is being paid to the subject of meat preserving, not there only, but in all the colonies. A bill, offering 10,000 acres of land as a premium to the first party who lands 100 tons of sound uncooked meat in Europe, has been before the Legislative Council, and will probably become law. A desirable impetus will

thus be given to the exportation of the surplus fat stock. Boiling down is becoming prevalent in all parts of the colony.

Colonial Railways.—The *Perth Gazette* says:—Among other panaceas for promoting the success of the colony which has lately been brought forward, and perhaps will be brought before the Council for discussion, is that of the construction of a railway or tramway between some central point in the corn-producing eastern districts and the seaport, the argument being that the colony having now gone beyond the point of home-consumption of bread-stuffs, the means of cheap transport are absolutely necessary to enable it to increase its production and to export with any hope of profit; also that permanent means of transport would induce settlement upon, and the cultivation of, the good land in the east district, now only devoted to pasturage.

Obituary.

The Marquis of Salisbury, K.G., died suddenly, on Sunday last, at Hatfield House, Hertfordshire. He was the only son of James first Marquis of Salisbury, by his wife, Lady Mary Emily Hill, second daughter of the first Marquis of Downshire. He was born April 17, 1791; consequently, had he lived a few days longer, he would have attained his seventy-seventh year. He succeeded to the family honours on the death of his father, June 13, 1823. The deceased marquis was twice married—first, Feb. 2, 1821, to Frances Mary, only daughter and heir of Mr. Bamber Gascoyne, who died on October 15, 1839; and secondly, he married, on April 29, 1847, Lady Mary Catherine Sackville West, second daughter of the Earl Delawarr. By his first marriage he leaves surviving issue Lady Mildred, married to Mr. Alexander J. Beresford Hope, M.P.; Lady Blanche, widow of Mr. James Maitland Balfour, of Whittinghame; Viscount Cranborne, M.P. for Stamford; and Lord Eustace Cecil, M.P. for South Essex. By his second marriage his lordship leaves issue three sons, viz., Lord Sackville, Lord Arthur, and Lord Lionel Cecil; and Ladies Mary Arabella and Margaret Elizabeth Cecil. The Marquis of Salisbury was appointed lord-lieutenant of the county of Middlesex on the resignation of the late Duke of Portland; was made a D.C.L. at Oxford in 1834, and was created a Knight of the Garter in 1842. He had been colonel of the Hertfordshire Militia since 1851, and was major of the South Hertfordshire Yeomanry Cavalry from 1847 to 1854. He was appointed a deputy-lieutenant of Argyleshire in 1859, and on the resignation of the late Lord Dacre was unanimously elected chairman of the Herts Quarter Sessions. He accepted office in the Earl of Derby's first administration, in 1852, as Lord Privy Seal; and again, in Lord Derby's government, from February, 1858, to June, 1859, as Lord President of the Council. He was elected a member of the Society of Arts in 1858, and filled the office of Vice-President for some years, taking a warm interest in many of the Society's proceedings, and being always ready, at any time, to aid it with his valuable influence and advice.

Notes.

Russian Game in Paris.—During the last few weeks the shops of Paris have exhibited a considerable number of strange water-fowl, and magnificent specimens of the great grouse, the cock of the woods. These birds come from Russia, and arrive at the Paris market in considerable quantities twice a week, special arrangements having been made with the railway authorities both with respect to rates of carriage and early delivery. The three kinds quoted in the official lists are:—Cocks of the woods, 8 to 11 frs. each; gelinottes, 3fr. 50c. to 4fr. 50c.; and logapèdes, 2 fr. to 2fr. 75c. The gelinotte has become a favourite in Paris, as the price will show, for the birds are small, about the size of a widgeon. The crops are found full of the buds of the willow or other trees, which seem to be the usual food of the birds, for the skin exudes a resinous matter, which, without care in the cooking, is extremely disagreeable, but which is easily removed by means of warm water or milk. The best treatment, however, is said to be to keep the birds in hot milk for several hours before dressing them, when they become extremely delicate. Immense flocks of woodcocks are just now passing over Russia towards the north, but their admission is prohibited by the French game regulations.

Competition in France for Poems to be set to Music.—The new system of competition for the lyric theatres of Paris has commenced with the Grand Opera. The time for sending in compositions to be set to music elapsed a fortnight since, when 168 works had been received from Paris and the provinces. The authors of these productions were invited to meet in the bureau of the Director-General of Theatres, to elect a jury of nine members, with as many supplementary names, and fifty-six responded to the invitation. The nine jurors elected are MM. Perrin, director of the Opera, Gounod, Félicien David, Ambrose Thomas, Emile Augier, Théophile Gautier, Paul St. Victor, F. Sarcey, and Victor Massé, four being musicians and four writers. The authors of the poems sent in for competition expressed a desire that besides the prize poems the five compositions considered next in merit shall be announced in the order in which they shall be placed by the jury by their titles and mottoes; and that similar competitions shall take place at fixed periods. The commission has now made its report. Seventeen of the works sent in were first selected, as deserving of careful examination, and from these five were eventually selected, as possessing considerable merit, and the work selected for the prize is described as in most respects very remarkable; the subject is from Russian history, is said to be treated in a grand, poetic, and varied manner. As soon as the award of the commission shall have been approved by the Emperor, composers will be invited to set it to music.

Correspondence.

Railway Management.—Sir,—In the valuable papers on railway management which have lately been read before the Society of Arts, attention has been greatly directed to the means of reducing expenses, and very little to a topic no less important—the increase of revenue. It is generally assumed that all traffic does and must come upon a railway; and yet, with regard both to income and expenditure, it is questionable whether all that can be has been realised in this country, and whether we have all the fruits of good management. Many years ago the same remarks were made as now about the larger results of French railways in a poorer country, and with a population less commercial, and supposed to have less aptitude as men of business. I made it, therefore, a matter of investigation, to ascertain the French system of management; and in 1851 I published some observations in a railway paper. They were well received, and met with attention, but, in the end, they produced little practical effect, as our own management has been supposed to be sufficient, and now we find ourselves in the same situation as before. All my subsequent observations have led to the same conviction—that the English system of a g n ral manager or goods manager is vicious; and the mischiefs are not confined to this country, but propagated by us in those foreign countries where we establish railways, and hence the

very heavy losses to which shareholders in such undertakings are subjected, particularly in the early years of working. As the French system is very simple, it may be useful to describe it, and it is as well to begin at what may be considered the wrong end. One chief key to French working is the Statistical-office, not the Audit-office, but one distinct. On an ordinary line this will consist of a superintendent, at £200 a-year, and a couple of clerks. On a very great line more will be required, but under no circumstances is the expense large, for there is mere clerk's work carried out on printed forms, and such an office soon pays itself. In this office each train is worked out in every statistical detail, as if for a minute Governmental return—its passengers, receipts, station traffic, goods, consumption of fuel, cost, &c. Each train is watched. If found to be increasing or too cumbrous, the result suggests an augmentation of trains; if falling off, then some train is stopped, not at haphazard, but at an hour convenient to the traffic. If a station falls off it is reported, and inquiry made as to the cause, whether temporary or permanent, and it is dealt with accordingly. Thus an investigation is constantly proceeding, apart from the administrative authorities, which enables them to take their measures with certainty, so as to conform, as far as possible, to the necessities of the traffic, and not to attempt the conforming of the traffic to the ideas of the goods or locomotive manager. The audit department is, as here, an audit or check on the tickets or vouchers. Its tabulated results pass to the statistical department, and constitute the basis of much of its operation, but the locomotive and all distributing departments contribute to the statistics. Of the locomotive and goods department, it is unnecessary to say more than this, that they generally conform to the English departments, but there is a material difference in the administration of the goods department, resulting from the circumstance that the manager is stationary in his office, that he has the assistance of the statistical department, and that all outdoor touting and bargaining is done by the commercial agents. The commercial agents constitute a department, and an important one, in the French system. They are young men, with small allowances, who are, in fact, the commercial travellers for the railway. It is their business to see that all the produce of the country comes on the railway, and to allow none to go by road, river, canal, or sea, which can be secured. They must look after every source of traffic, great or small; each mill, farm, and quarry, and make the best bargains they can. When this comes to be discussed before the traffic committee, the general manager, or goods manager has only to say whether they can carry it, and the traffic committee decide on the contract. The French companies began on the English system, and even with Englishmen, and at the time I made my first inquiries the experience of the English system was still fresh and unfavourable. The French administrators found a great objection to a goods manager running about everywhere over the country. They found he had not the time for small operations, and neglected them, and neglected, at the same time, the conduct of his own official duties. They therefore consider it a great advantage that he shall be relieved from the necessity of seeking out traffic, and have it brought to him, thereby devoting his undivided energies to the working of the traffic, in which he is materially assisted by the condensed information of the statistical department. The principle is the division of labour, with precision of administration. The commercial agent is a functionary in strict conformity with commercial practice, and indeed all the arrangements are thoroughly practical and systematic. The French administration is further helped by a thoroughly good constitution of the staff. Although the salaries are moderate, every one is well provided for, not on the footing of a driver's or servant's charity poundage and charity dole, but on that of great public establishments, conferring privileges on its members of all degrees. The French companies pay more in this way and less in salaries, and in the end the French railway *employé*, high or low, is better off than the English, all things considered. On this head a very remarkable article will be found in a recent number of the *Revue des Deux Mondes*, which institutes a comparison altogether unfavourable to the English staff, the advantages enjoyed by a French *employé* being enough to make the hair of an English director stand on end. There is no one in the service of the English Government possesses equal advantages, not even a sailor. There is no grinding down, there are high retiring pensions, sick allowances, medical service, and all the benefits of co-operation in the purchase and supply of eatables and necessaries, which are conveyed free by the companies. The organisation of the Paris and Mediterranean service has been brought to a very high pitch. Of course we may be told that everything exists in England,—statistics, goods agents, every means for getting goods, and that *employés* are indulgently treated. In sober truth there is nothing of the kind; and on the best managed lines everything is capricious for want of system. The inferior clerks and servants, unless *protégés* of some powerful favourite, are subject to constant vexations. The removal of a family and furniture on duty is sometimes made a matter of harsh treatment. There is no assurance of fair advancement, and no prospect of fixed employment, except at a low salary, and he who obtains an advance after long years of service may find himself cut down by a committee of inquiry or new board. The first operation of a reforming chairman or opposition board is to cut down the salaries, though with the certain effect of restoring them to the old level in two or three years, the efficiency of the staff having been much damaged in the meanwhile. The percentage system for increase of traffic and diminution of expenses is fully carried out in France, and has never been adequately applied in England, though it was here the allowance on saving of coke was first introduced. It might have been thought that a principle found successful would have been more freely applied, but the political changes of administration, consequent on ill-success, and the operations of committees of inquiry have generally been unfavourable to liberal and systematic treatment of *employés*. The benefit of a good and reliable staff is a great advantage to the French manager. The man, high or low, is bound up with the service for his life, he can scarcely get anything better elsewhere after a few years' duty, and dismissal would be the loss of a valuable property. Every year of the company's success brings greater privileges to himself, however humble may be his branch of employment, and, if in the higher ranks, he has a direct interest in promoting economy and prosperity, which yield him an annual bonus. The system here described is not the sole cause of French success, but it greatly contributes to this, for it is businesslike and justified by common sense, while our practice is unbusinesslike. There are arrangements in France in conformity with French ideas, which greatly reduce expense, but our people are not so ready to sacrifice time for advantages they consider questionable. The details of the French system here described are thoroughly applicable at home, and, if applied, they would not only do no harm, but must result in great pecuniary advantage.—I am, &c., HYDE CLARKE.

32, St. George's-square, S.W., April 11, 1861.

MEETINGS FOR THE ENSUING WEEK.

MON......Society of Engineers, 7½. Adjourned discussion "On the Sewerage Works at Redhill," by Mr. Sydney A. Reade.
R. United Service Inst., 8½. Capt. T. B. Heathorne, "A Muzzle-pivoting Gun Carriage, on the Lever and Fulcrum Principle."
Asiatic, 3.
Victoria Inst., 8.

TUES ...Civil Engineers, 8. 1. Mr. A. Wilson, "Irrigation in India." 2. Mr. T. Login, "On the Benefits of Irrigation

in India; and on the proper Construction of Irrigating Canals." 3. Mr. Geo. Higgin, "Irrigation in Spain, chiefly in reference to the Construction of the Henares and the Esla Canals in that Country."
Statistical, 8. Mr. Samuel Brown, "On the Population Statistics of Europe."
Pathological, 8.
Ethnological, 8. 1. Mr. Fred. Whymper, "On the Natives of the Alaska Province of Russian America." 2. "On the Wild Tribes of Southern India," from the Records of the India Office.
Royal Inst., 3. Dr. M. Foster, "On the Development of Animals."

Wed ...Society of Arts, 8. Mr. W. A. Gibbs, "On the Cultivation of Beetroot, and its Manufacture into Sugar."
Geological, 8. 1. Mr. George Maw, "On the Distribution of Iron in variegated Strata." 2. Dr. H. B. Holl, "On the older Rocks of South Devon and East Cornwall."
R. Society of Literature, 4½. Annual Meeting.
Archæological Assoc., 8½.

Thur ...Royal, 8½.
Antiquaries, 2. Annual Meeting.
Zoological, 8½.
R. Society Club, 6.
Mathematical, 8.
Royal Inst., 3. Dr. W. Odling, "On Chemical Combination."
Society of Fine Arts, 8. Exhibition of a part of the Drawings and Sketches of John Constable, R.A.

Fri......Royal Inst., 8. Dr. Gladstone, "On some New Experiments on Light."
R. United Service Inst., 3. Commander F. Warren, "Cooking for Troops." (M. Sorensen will exhibit his Norwegian self-acting apparatus.)

Sat......R. Botanic, 3¾.
Royal Inst., 3. Dr. Odling, "On Chemical Combination."

Patents.

From Commissioners of Patents' Journal, April 10.

Grants of Provisional Protection.

Animal and vegetable substances, drying and preserving—1030—M. B. Orr.
Axles, &c., lubricating—1007—A. Elliott and J. Barker.
Bale ties—981—W. R. Lake.
Bale ties—1079—J. F. Hadland.
Blow-pipes—963—J. O. Spong and J. F. Haddaway.
Boiler flues, &c., cleaning—1047—I. Bates and J. Taylor.
Boilers, &c.—1039—W. S. Page and R. East.
Boots and shoes—1065—J. Macintosh and W. Boggett.
Braces—971—T. Pope.
Carriages—992—T. W. Fuller.
Cement, manufacturing—1045—A. Warner.
Chemical substances to be used in preparing paper pulp—1050—F. Bauman.
Cocks and taps—1031—W. H. S. Aubin.
Collars, cuffs, &c.—1040—B. Browne.
Conveyance, &c., appliances for—961—G. Macdona and O. Hilliard.
Cork, treating—1077—J. H. Johnson.
Cylinders, drying, of sizing and other machines—1012—G. Hayhurst.
Engines—991—W. R. Boothby.
Engines—1056—W. E. Newton.
Engines, locomotive, &c.—1034—W. Clark, jun., and J. Clark.
Engines, steam—1011—J. Warburton, jun.
Engines, steam—1033—H. Davey.
Engines, steam—1052—G. Davies.
Esparto, &c., bleaching—1044—T. Routledge and W. H. Richardson.
Fabrics, cut-pile—1060—S. C. Lister.
Fabrics, woven, producing designs upon—1051—G. Hodgkinson.
Fabrics, &c., washing, bleaching, &c.—1072—O. Ormrod.
Filters—1070—W. R. Lake.
Fire-arms, breech-loading—1054—C. E. Brooman.
Fire-arms, &c.—1024—H. G. P. Meade.
Flasks, dram—1017—J. Plant.
Furnaces, blast—1020—T. Whitehouse.
Furnaces, smoke-consuming—990—W. E. Gedge.
Furnaces, &c.—753—C. Schinz.
Gaseliers—1066—C. Joyner.
Grease cups—979—C. N. Leroy.
Ice, &c., producing—1006—R. Little.
Iron—1073—C. F. Claus.
Iron—1074—C. F. Claus.
Iron, &c., coating—1067—J. C. Coombe and J. Poole.
Iron and steel—965—H. Bessemer.
Iron and steel—967—H. Bessemer.
Iron and steel—1071—H. Armstrong.
Iron and steel—1076—J. H. Johnson.
Kilns for burning bricks, &c.—1038—W. D. Cliff.
Knives, pocket—1003—A. V. Newton.
Ladles containing molten metal, support for—1062—J. G. Fildes.
Lamps—973—S. Holmes.
Lamps—1043—J. H. Johnson.
Letter clips, bill files, &c.—1041—S. Perry and F. Brampton.
Linen, &c., extracting ink and iron-mould from—3625—B. Engel.
Looms—1014—T. Lane.
Looms—1021—T. Sagar, T. Richmond, and C. Catlow.
Looms—1042—J. Lyall.
Mashing apparatus—1009—A. McGlashan and J. Hendry.
Metal bars for horse-shoes, &c.—994—E. Gray.
Milk, preserving—1063—T. C. Currie.
Millstones, dressing—1028—J. T. King.
Mines, &c., hauling minerals in—1058—J. G. Jones.
Motive-power from rivers, &c.—705—L. Roman.
Needles, securing and wrapping up—1055—C. B. James.
Optical illusions, producing—1049—J. Maurice.
Paper bags, machinery for making—1001—C. Harris.
Paper-cutting machines, &c.—1032—T. Bettney.
Paper, safety—1023—J. Jameson.
Paper tubes for spinning machinery—1015—C. E. Brooman.
Pencils, indelible—977—C. McDermott.
Persons, deaf or dumb, apparatus for communicating with—1075—B. Mitford.
Pistons—1035—M. Havenhand and J. Allen.
Postage stamps, &c., moistening—1069—W. E. Gedge.
Presses, hydraulic—1029—W. Oram.
Railway points and signals—1013—W. Buck.
Railway rails—989—H. Burgess.
Railway signals—987—J. S. Farmer.
Railway trains, stopping—1080—F. Wirth.
Railways—1068—W. J. Addis.
Reaping and mowing machines—1037—W. Manwaring.
Seeds and oil nuts—1081—J. M. Day.
Seeds, &c., decorticating—1084—J. Walker and J. Wharrie.
Sewing machines—856—E. K. Dutton and J. and H. Holme.
Sewing machines, &c., stands for—951—W. and C. E. Taylor.
Sheep, &c., shearing—1053—P. Adie.
Ships' hatches, &c.—997—J. A. Farrar and B. R. Huntley.
Shirt and waistcoat combined, &c.—927—S. Wenkheim.
Shutters, iron—1064—H. G. Warren, S. Stuckey, and P. Froud.
Slate, &c., working and manufacturing—1027—E. J. J. Dixon.
Spinning machinery—1018—A. V. Newton.
Spirits, distilling and rectifying—983—E. Vignier.
Steel, &c.—1078—J. H. Johnson.
Streets, &c., cleaning—941—R. W. J. Trueman.
Tables, portable—999—D. Lewis.
Telegraphic apparatus—1026—W. P. Piggott.
Thrashing machinery—985—A. V. Newton.
Tiles, ornamenting—1016—S. Fisher.
Traps for catching mice, &c.—849—W. E. and F. A. Bush.
Traps, stench—1002—J. Antill.
Trowsers—1036—J. Cocks.
Valves for regulating the flow of water—969—E. K. Dutton.
Valves made from india-rubber, &c.—118—W. Firth.
Watches, &c.—993—C. D. Abel.
Whist counters—1057—H. Jones, jun., and W. F. De La Rue.
Wool-cleaning machines—1019—W. Richardson.
Wool, &c., carding—1022—J. Anderson.

Invention with Complete Specification Filed.

Engines, &c., packing for—1120—W. E. Boardman.
Horse-shoe nails, manufacturing—1110—W. R. Lake.
Iron and steel—1167—A. L. Holley.
Liquids, measuring—1128—C. W. Baldwin.
Railways—1159—C. Desnos.

Patents Sealed.

2846. C. Avery.	2891. H. A. Bonneville.
2849. A. F. Hobhouse.	2912. J. Rives.
2850. W. R. Lake.	2917. G. M. Wells.
2853. R. George.	2929. J. Seward and H. Smith.
2855. E. Haigh.	2944. J. Schwartz.
2857. J. C. Wilson.	2955. J. Hunter.
2861. A. Helwig.	3033. C. E. Brooman.
2868. J. Buckingham and J. S. Blockey.	3123. A. V. Newton.
2872. H. A. Dufrené.	3129. H. A. Bonneville.
2873. R. Canham & J. Thomson.	3219. A. V. Newton.
2878. B. Nicoll.	3301. W. J. Murphy.
2882. E. Ward.	3359. E. Belknap.
2883. W. Gadd and B. Walker.	313. W. Guise.
	464. F. Schiifer.

From Commissioners of Patents' Journal, April 14.

Patents on which the Stamp Duty of £50 has been Paid.

1039. H. Bridson.	1104. D. Greig.
989. E. Welch.	1041. F. P. Warren.
1024. S. Wright.	1026. D. Payne.
1045. J. M. Hart.	1038. J. Haworth.
1046. T. J. Mayall.	1047. F. Bapty and E. B. Sayers.
1051. A. V. Newton.	1048. G. Jackson.
1077. A. W. Hale.	

Patents on which the Stamp Duty of £100 has been Paid.

876. F. Taylor.	1009. E. H. Bentall.
858. H. Wilde.	891. J. Lancelott.
927. F. Gye.	892. T. Don, T. Smith, and L. Horsfield.
933. R. Ransome.	